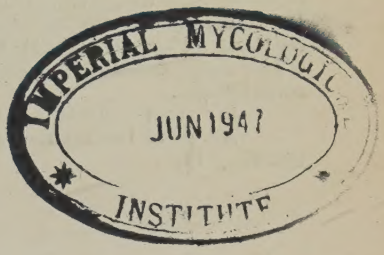
COMPTES RENDUS

(DOKLADY)

DE L'ACADÉMIE DES SCIENCES DE L'URSS

NOUVELLE SÉRIE

1945



VOLUME XLVIII

№ 9

ÉDITION DE L'ACADÉMIE DES SCIENCES DE L'URSS
MOSCOU

AVIS AUX AUTEURS

Les «Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS» paraissent tous les dix jours. Neuf numéros composent un volume pourvu d'une table des matières. Il y a quatre volumes par année.

Les «Comptes Rendus de l'Académie des Sciences de l'URSS» en de courtes communications précisent l'essentiel des travaux en préparation. Ces articles, ne dépassant pas en règle générale quatre pages, sont donnés en anglais ou en français. Ils embrassent les sciences mathématiques, physiques, naturelles et appliquées, mettant au jour les résultats de recherches scientifiques en cours ou qui viennent d'être achevées, et représentant ainsi les plus récentes données de l'investigation scientifique.

L'auteur a droit à 50 exemplaires de son article.

Adressez les manuscrits à la Rédaction des «Comptes Rendus», Moscou, Wolkhonka, 14.

30 Septembre

COMPTES RENDUS

(DOKLADY)

DE L'ACADÉMIE DES SCIENCES DE L'URSS

COMITÉ DE RÉDACTION

A. Arbusov, de l'Académie, V. Chlopin, de l'Académie, A. Deborin, de l'Académie, A. Frumkin, de l'Académie, A. Kolmogoroff, de l'Académie (vice rédacteur), L. Orbeli, de l'Académie (rédacteur en chef), A. Richter, de l'Académie, S. Soboleff, de l'Académie, S. Vavilov, de l'Académie (vice rédacteur)

NOUVELLE SÉRIE

13-me année

Paraissant tous les dix jours

1945

VOLUME XLVIII, № 9

TABLE DES MATIÈRES

Pages

MATHÉMATIQUES

G. Iegudin. Parameters of Distribution of a Random Variable Invariant under Translations, and Algebraic Semi-invariants 615

S. L. Soboleff, de l'Académie. Sur la presque périodicité des solutions de l'équation des ondes. II 618

HYDRAULIQUE

F. A. Trebin, S. A. Khristianovich, Member of the Academy, and V. I. Chernikin. Isothermal Flow of Gas in Tubes with a Rough Surface 621

GÉODÉSIE

V. A. Kazinsky. On the Application of Curvatures 622

PHYSIQUE MATHÉMATIQUE

D. I. Scherman. On Diffraction of Elastic Waves 626

PHYSIQUE

E. Adirovich. Propagation of Waves and Retardation of Electron Beams in Plasma 630

B. M. Wul, Corresponding Member of the Academy, and L. F. Vereshchagin. Dependence of the Dielectric Constant of Barium Titanate upon the Pressure 634

PHYSIQUE BIOLOGIQUE

M. M. Gurewitsch. Spectrum Sensitivity of the Three Receptors of the Eye . 637

CHIMIE

P. V. Zimakov et V. A. Pokrovsky. Transformation catalytique de l'alcool allylique en acroléine par oxydation 641

CHIMIE PHYSIQUE

N. S. Akulov, Member of the Academy of Sciences of the Belorussian SSR. On the Relation between the Induction Period and the Chemism of a Reaction 644

CHIMIE DU GLOBE

S. I. Sinlakova. On the Distribution of Lead in Soils 648

CHIMIE BIOLOGIQUE

N. A. Maximov, Corresponding Member of the Academy, **J. V. Rakitin** and **R. Kh. Turezkaya.** A Procedure Ensuring the Preservation of Vitamin C in Leaves of Gladiolus Prepared for Storage 651

G. A. Zepkova. Concentration of Vitamin C in Certain Plant Species of Central Asia 655

GÉOLOGIE

C. G. Zlatkind. The Kovdoro-lake Pluton of Alkaline and Ultrabasic Rocks 659

A. A. Polkanov, Member of the Academy. The Principal Theses of the Genetic Systematics of Intrusive Bodies 662

V. N. Saks. Kaolins in the North of the West-Siberian Lowlands and their Significance for the Knowledge of the Structure of the Region 666

ÉCOLOGIE

G. I. Poplavska. On Winter Transpiration in Different Geographical Races of the Same Plant Species 670

V. B. Sochava. Ecological Relicts of Manchurian Flora Considered in Connexion with Certain Palaeogeographical Restoration 674

MORPHOLOGIE EXPÉRIMENTALE

L. Zhinkin. Regeneration of Muscles in *Mammalia* 678

ZOOLOGIE

S. Gershenson. Seasonal Fluctuations in the Frequency of Black Hamsters 681

A. A. Stackelberg. Some New Data on the Status of the Genus *Myennis* R. D. *(Diptera, Otitidae)* 684

HELMINTHOLOGIE

T. S. Skarbilovich. A Contribution to the Knowledge of the Biological Cycle of *Capillaria mucronata* (Molin, 1858), a Nematode of the Bladder of Sable, Marten and Mink 687

Le présent numéro est suivi de l'indice du volume XLVIII

Traductions rédigées par D. Rakhmanov et T. Rogalina

Édition de l'Académie des Sciences de l'URSS
Moscou 1945

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

MATHEMATICS

PARAMETERS OF DISTRIBUTION OF A RANDOM VARIABLE INVARIANT UNDER TRANSLATIONS, AND ALGEBRAIC SEMI-INVARIANTS

By G. IEGUDIN

(Communicated by A. N. Kolmogoroff, Member of the Academy, 8. XII. 1944)

Having investigated various particular systems of linearly independent semi-invariants of the binary form

$$F = \sum_{h=0}^{n} C_n^h b_h x^{n-h} y^h$$

Dressel (1) proved that some of them are reduced to parameters of distribution, while others, possessing a number of interesting properties, may likewise be used as such parameters. By a semi-invariant of the form F is meant a function of the coefficients of F which rests invariant under any transformation

$$x = \xi + a\eta, \quad y = \eta \tag{1}$$

This is no mere coincidence. In fact it is only natural for the mathematical statistics to consider the parameters independent of the origin of coordinates as quantities characterizing the distribution of a random variable, with the exception of the mean. It is possible to prove

Theorem. *Suppose that the quantities* $m_h (h = \overline{1, n})$ *entering the coefficient of the binary form*

$$\Phi = \sum_{h=1}^{n} C_n^h m_h x^{n-h} y^h \quad (m_0 = 1) \tag{2}$$

represent the initial moments of a random variable X, *and* θ_r *is a parameter of distribution of* X *which depends only on the initial moments* $m_h (h = \overline{1, r})$, $r \leqslant n$. *Then:*

1) *If* $\theta_r = f(m_1, m_2, \ldots, m_r)$ *rests invariant under the translations of* X, *then* $f(m_1, m_2, \ldots, m_r)$ *is a semi-invariant of the form* (2).

2) *If* $f(m_1, m_2, \ldots, m_r)$ *is a semi-invariant of the form* (2), *then* $\theta_r = f(m_1, m_2, \ldots, m_r)$ *is a parameter of distribution of* X *which rests invariant under the translations of* X.

The proof of the theorem follows immediately from comparison of the coefficients of the initial form with those of the transformed form, on the one hand, and, on the other hand, from comparison of the initial moments of the random variable X with those of $X + a$.

In fact, the transformation (1) converts Φ into

$$\Phi = \sum_{h=0}^{n} C_n^h (\xi + a\eta)^{n-h} \eta^h = \sum_{h=0}^{n} C_n^h \left(\sum_{j=0}^{h} C_h^j a^{h-j} m_j \right) \xi^{n-h} \eta^h \tag{3}$$

On the other hand, the characteristic function $\varphi_X(t) = \int_{-\infty}^{\infty} e^{itx} dF(x)$ of the random variable X is connected with that of $Y = X + a$ by the relation

$$\varphi_Y(t) = e^{ita} \varphi_X(t) \tag{4}$$

Hence

$$m_h(Y) = \frac{1}{i^h} \left\{ \frac{d^h}{dt^h} \left[e^{ita} \varphi_X(t) \right] \right\}_{t=0} = \frac{1}{i^h} \sum_{j=0}^{h} C_h^j a^{h-j} i^{h-j} \left[\frac{d^j \varphi_X(t)}{dt^j} \right]_{t=0} =$$

$$= \sum_{j=0}^{h} C_h^j a^{h-j} m_j(X) \tag{5}$$

where $m_h(X)$ and $m_h(Y)$ denote the initial moments of the h order of the variables X and Y, respectively.

Dressel also found parameters (of odd and even orders separately) possessing a remarkable property. To formulate this property clearly we first introduce

Definition. A statistic $t_r \equiv \dot{\theta}_r$ of a sample $S'(x_i, n)$ $(i = \overline{1, n})$ from a general population (finite or infinite, discrete or continuous) and the parameter θ_r of this general population are said to correspond to one another, if $t_r \equiv \dot{\theta}_r$ depends on the initial sampling moments $\dot{m}_i$ in the same way as θ_r depends on the population moments m_i, that is, if $\theta_r = f(m_1, m_2, \ldots, m_r)$ and $\theta_r = f(m_1, m_2, \ldots, m_r)$, where $\dot{m}_h = 1/n \sum_{i=1}^{n} x_i^h$ and $m_h = \int_{-\infty}^{\infty} x^h dF(x)$, provided the integral $\int_{-\infty}^{\infty} x^r dF(x)$ exists, ($F(x)$ denotes here the distribution function of X).

Let us define the ρ-parameters of distribution on a random variable X with the characteristic function $\varphi(t)$ by means of the generating function $\omega(t)$

$$\frac{d\omega(t)}{dt} = [\varphi'(t) - \varphi'(0)\, \varphi(t)]\, \varphi(-t) \tag{6}$$

Hence

$$\rho_r = \frac{1}{i^r} \left[\frac{d^r \omega(t)}{dt^r} \right]_{t=0} \tag{7}$$

In case the distribution is symmetric, *i. e.* $F(x) = 1 - F(x)$, $\varphi(t)$ is an even function and

$$\omega(t) = \frac{1}{2} [\varphi(t)]^2 \tag{8}$$

For every distribution with $\int_{-\infty}^{\infty} x^r dF(x) < \infty$ the equalities (6) and (7) give explicit expressions of ρ_r for every r through the initial moments of the distribution

$$\rho_r = \sum_{i=1}^{r-2} C_{r-1}^i (m_{r-} - m_1 m_{r-1-i})\, m_i\, (-1)^i \tag{9}$$

The expressions of ρ_r through the central moments μ are more simple

$$\rho_r = \mu_r + \sum_{i=2}^{r-2} C_{r-1}^i \mu_{r-i}\, \mu_i\, (-1)^i \tag{10}$$

If $\dot{\rho}_r$ is the statistic of a repeated sample of size n corresponding to the population parameter ρ_r defined by (7) and (6), then it is possible to prove that

$$E(\dot{\rho}_r) = \begin{cases} \dfrac{n-1}{n}\,\rho_r & \text{for even } r \\ \dfrac{(n-1)(n-2)}{n^2}\,\rho_r & \text{for odd } r \end{cases} \tag{11}$$

The proof can be obtained immediately by using an operator formula which is a natural generalization of Romanovsky's formulae ([2]). Namely, it is easy to prove that

$$E(\dot{m}_a^{\alpha}\dot{m}_b^{\beta}\ldots\dot{m}_f^{\varphi}) = O_{a,b,\ldots,f}^{\alpha,\beta,\ldots,\varphi}(m_0^n) \tag{12}$$

where the differential operator O follows the usual rules of differentiation of sums, products, powers and composite functions, and, besides, satisfies the conditions:

$$O_{a,b,\ldots,f}^{\alpha,\beta,\ldots,\varphi}(U) = O_a^{\alpha}[O_{b,\ldots,f}^{\beta,\ldots,\varphi}(U)], \quad O_a^{\alpha}(U) = O_a[O_a^{\alpha-1}(U)],$$

$$O_a(m_k^{\gamma}) = \frac{\gamma}{n}\, m_k^{\gamma-1} m_{k+a}.$$

After having applied the operator we put $m_0 = 1$.

We call a sample statistic t an unbiassed estimate of the population parameter θ if $E(t) = \theta$.

The property (11) of the ρ-parameters enables us to construct their unbiassed estimates easily. For if the l-statistic of a repeated sample of size n is defined by the equalities

$$l_r = \begin{cases} \dfrac{n}{n-1}\,\dot{\rho}_r & \text{for ever } r \\ \dfrac{n^2}{(n-1)(n-2)}\,\dot{\rho}_r & \text{for odd } r \end{cases} \tag{13}$$

then, by (11)

$$E(l_r) = \rho_r \tag{14}$$

for every r.

Institute for Mathematics and Mechanics.
Uzbek SSR Academy of Sciences.

Received
28.X.1944.

REFERENCES

[1] P. Dressel, Ann. Mathem. Statistics, **11**, 1, 33 (1940). [2] V. Romanovsky, Metron, **8**, 1—2, 1 (1929).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

MATHÉMATIQUES

SUR LA PRESQUE PÉRIODICITÉ DES SOLUTIONS DE L'ÉQUATION DES ONDES. II

Par S. L. SOBOLEFF, de l'Académie

Dans la Note précédente (1) nous avons démontré que les solutions de l'équation des ondes à coefficients constants sont presque périodiques.

Il est connu que cette presque périodicité est une conséquence du fait que la trajectoire de la solution est compacte dans un espace de Hilbert H convenablement choisi.

Le point principal de la démonstration était d'établir l'existence d'une nouvelle intégrale quadratique de l'équation des ondes qui diffère de l'intégrale de l'énergie. Cette intégrale qui contient les dérivées secondes de la fonction inconnue est une forme positive par rapport à ces dérivées. Cela nous a permi de démontrer à l'aide d'un théorème de Kondrachoff que les premières dérivées sont compactes dans L_2. La compacité de la trajectoire dans H en résultait immédiatement.

Dans la présente Note nous donnons une généralisation des résultats précédents pour l'équation des ondes à coefficients variables.

Considérons l'équation

$$\sum_{i=1}^{n}\sum_{j=1}^{n}\frac{\partial}{\partial x_i}A_{ij}\frac{\partial u}{\partial x_j}-Cu=\mu\frac{\partial^2 u}{dt^2} \tag{1}$$

où A_{ij}, C et μ sont des fonctions quelconques des variables $x_1, \ldots, x_n$ (ne dépendant pas de t), définies dans un domaine Ω borné par un contour S assez régulier. Nous supposons que ces fonctions admettent un certain membre de dérivées continues.

Supposons encore que

$$\mu>0, \quad C\geqslant 0$$

et que la forme

$$\sum_{i=1}^{n}\sum_{j=1}^{n}A_{ij}\,p_i\,p_j$$

est une forme quadratique positive définie des arguments $p_1, \ldots, p_n$.

Construisons l'espace H de Hilbert dont les éléments h sont des paires de fonctions u_0, u_1, définies dans le domaine Ω. Le produit scalaire dans H de deux éléments h et g sera défini par la formule

$$(h,\,g)=\overbrace{\int\cdots\int}^{n}_{\Omega}\left(\sum_{i=1}^{n}\sum_{j=1}^{n}A_{ij}\frac{\partial u_0}{\partial x_i}\frac{\partial \bar{v}_0}{\partial x_j}+Cu_0\bar{v}_0+\mu u_1\bar{v}_1\right)d\Omega \tag{2}$$

(les notations sont les mêmes que dans l'article (1)).

Examinons les solutions de l'équation des ondes (1), satisfaisant à l'une des conditions suivantes:

I) $$u|_S = 0$$

ou

II) $$\frac{\partial u}{\partial \nu}\Big|_S = \sum_{i=1}^{n}\sum_{j=1}^{n} A_{ij}\frac{\partial u}{\partial x_j}\cos nx_i\Big|_S = 0 \tag{3}$$

Si nous posons

$$u_s(x_1, \ldots, x_n, t) = u(x_1, \ldots, x_n, t); \quad u_1(x_1, \ldots, x_n, t) = \frac{\partial u}{\partial t}(x_1, \ldots, x_n, t)$$

chaque solution de (1) forme une trajectoire dans H, de même que pour l'équation des ondes à coefficients constants.

Soit $h(t)$ et $g(t)$ des trajectoires quelconques. Il est connu que

$$\frac{d}{dt}(h(t),\ g(t)) = 0 \tag{4}$$

La relation (4) s'appelle théorème de l'énergie. Il en résulte que $(h(t), g(t)) = \text{const}$ et en particulier

$$E_1(u) = \|h(t)\|^2 = \text{const} \tag{5}$$

Par définition (h, g) est une intégrale de l'ensemble M_1 des trajectoires ayant des dérivées du second ordre. De (5) il suit que chaque trajectoire est entièrement située sur une sphère de l'espace H.

Indiquons une autre intégrale du problème. Soit h et g deux éléments quelconques de H admettant les dérivées continues nécessaires. Construisons l'intégrale

$$J_2(h, g) = \overbrace{\int \cdots \int}^{n}_{\Omega} \sum_{k=1}^{n}\sum_{j=1}^{n}\left\{\sum_{i=1}^{n}\sum_{l=1}^{n}\left(\frac{1}{\mu}\left[\frac{\partial}{\partial x_i}\left(A_{kl}\frac{\partial u_0}{\partial x_k}\right)\right]\left[\frac{\partial}{\partial x_l}\left(A_{tj}\frac{\partial \bar{v}_0}{\partial x_j}\right)\right] + \right.\right.$$

$$+ \frac{\partial \frac{1}{\mu}}{\partial x_i}\left(A_{kl}\frac{\partial u_0}{\partial x_k}\right)\left[\frac{\partial}{\partial x_l}\left(A_{ij}\frac{\partial \bar{v}_0}{\partial x_j}\right)\right] + \frac{\partial \frac{1}{\mu}}{\partial x_l}\left[\frac{\partial}{\partial x_i}\left(A_{kl}\frac{\partial u_0}{\partial x_k}\right)\right]A_{tj}\frac{\partial \bar{v}_0}{\partial x_j} +$$

$$+ \frac{\partial^2 \frac{1}{\mu}}{\partial x_i \partial x_l}A_{kl}\frac{\partial u_0}{\partial x_k}A_{tj}\frac{\partial \bar{v}_0}{\partial x_j}\Big) + A_{kj}\left(\frac{\partial u_1}{\partial x_k}\frac{\partial \bar{v}_1}{\partial x_j} + \frac{\partial u_0}{\partial x_k}\frac{\partial}{\partial x_j}\left(\frac{c}{\mu}\bar{v}_0\right) + \right.$$

$$\left.\left. + \frac{\partial \bar{v}_0}{\partial x_j}\frac{\partial}{\partial x_k}\left(\frac{c}{\mu}u_0\right)\right)\right\} d\Omega -$$

$$- \int \cdots \int_S \left\{\frac{1}{\mu}\sum_{k=1}^{n-1}\sum_{j=1}^{n-1}\sum_{i=l}^{n-1}\sum_{l=1}^{n-1}A^*_{kl}A^*_{tj}p^*_{il}\frac{\partial u_0}{\partial x^*_k}\frac{\partial \bar{v}_0}{\partial x^*_j} + \right.$$

$$\left. + \frac{\partial u_0}{\partial \nu}\frac{\partial \bar{v}_0}{\partial \nu}\left|\frac{\partial \frac{1}{\mu}}{\partial x^*_n} + \sum_{k=1}^{n-1}\frac{\partial}{\partial x^*_k}\frac{1}{\mu}\frac{A^*_{nk}}{A^*_{nn}} + \sum_{i=1}^{n-1}\sum_{l=1}^{n-1}\frac{1}{\mu}p^*_{il}\left(\frac{A^*_{nl}A^*_{nl}}{A^{*2}_{nn}} - \frac{A^*_{ll}}{A^*_{nn}}\right)\right|\right\} dS \tag{6}$$

On désigne ici par $x^*_1, \ldots, x^*_n$ le système des coordonnées cartésiennes locales, dont l'origine est située au point considéré de la surface S, et l'axe x^*_n coïncide avec la direction de la normale. Les coefficients A^*_{ij} sont les coefficients de l'équation (1) dans le nouveau système de coordonnées. Les p^*_{il} sont les dérivées

$$p^*_{il} = \frac{\partial^2 \psi}{\partial x^*_i \partial x^*_l} \tag{7}$$

où

$$x_n = \psi(x_1^*, \ldots, x_{n-1}^*) \tag{8}$$

est l'équation de la surface S.

On peut démontrer le théorème fondamental suivant

Sur l'ensemble M_2 des trajectoires dont les fonctions, qui les engendrent, ont des dérivées continues du troisième ordre dans Ω, et des dérivées secondes continues dans le domaine fermé, on a

$$J_2(h(t);\ g(t)) = \text{const} \tag{9}$$

Nous ne donnons pas la démonstration de ce théorème. Elle est basée sur une différentiation simple suivie d'une intégration par parties, et peut être faite d'une manière complètement analogue à celle qui a été donnée pour l'équation à coefficients constants.

La forme bilinéaire des dérivées secondes qui se trouve dans J_2 sous le signe d'intégrale par rapport à

$$\Phi(u_0, v_0) = \sum_{k=1}^{n}\sum_{j=1}^{n}\sum_{l=1}^{n}\sum_{i=1}^{n}\frac{1}{\mu}A_{kl}A_{ij}\frac{\partial^2 u_0}{\partial x_i\,\partial x_k}\frac{\partial^2 \bar{v}_0}{\partial x_l\,\partial x_j} \tag{10}$$

est positive définie, car une simple transformation affine peut réduire en chaque point de notre espace la forme $\sum_{k=1}^{n}\sum_{l=1}^{n}A_{kl}p_k p_l$ en une somme de n carrés $\sum_{k=1}^{n}p_k^{*2}$. La même transformation réduit la forme Φ en ce point à la forme

$$\sum_{i=1}^{n}\sum_{k=1}^{n}\frac{\partial^2 u_0}{\partial x_j\,\partial x_k}\frac{\partial^2 \bar{v}_0}{\partial x_j\,\partial x_k} \tag{11}$$

Par conséquent, la forme quadratique $\Phi(u_0, u_0)$ sera toujours positive pour chaque fonction u_0 dont les dérivées secondes ne sont pas nulles simultanément.

En répétant *mutatis mutandis* les raisonnements de la Note précédente, nous démontrons le théorème suivant.

Théorème. *Toutes les solutions de l'équation* (1) *ayant des dérivées continues jusqu'au troisième ordre dans* Ω, *et des dérivées secondes continues dans le domaine fermé, satisfaisant à l'une des conditions* (3), *sont des fonctions presque périodiques de* t.

Il est utile de remarquer que l'ensemble de toutes les intégrales quadratiques de l'équation des ondes n'est certainement pas épuisé par les deux intégrales considérées: $E_1(n)$ et la seconde intégrale positive $E_2(u) = J_2(h(t), h(t))$.

L'examen complet de toutes les intégrales quadratiques n'est pas le but de notre article.

Manuscrit reçu
le 11.V.1945.

LITTÉRATURE CITÉE

[1] S. L. Soboleff, C. R. Acad. Sci. URSS, XLVIII, No. 8 (1945).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

HYDRAULICS

ISOTHERMAL FLOW OF GAS IN TUBES WITH A ROUGH SURFACE

By F. A. TREBIN, S. A. KHRISTIANOVICH, Member of the Academy, and V. I. CHERNIKIN

The formulae that have heretofore been used in the design of gas-pipe lines, include dimensional empirical coefficients, determined by measuring the rate of gas flow in working pipe lines. All of them were established by studying the flow in gas pipes of relatively small diameter and operating under low pressures, that is for small Reynolds number.

But nowadays we build gas mains of large diameter, intended to work at high pressure, and in their case the use of the available formulae seems doubtful.

Prompted by this consideration the authors have made an attempt to construct a formula for the estimation of the rate of gas flow, based on the use of universal dimensionless coefficients of resistance.

To this purpose they have employed the equation for the constant rate of flow in gas tubes in conjunction with the equation of momentum. The gas flow was conceived as isothermal; the inertia forces, as negligibly small. Below is givan the design formula the authors thus obtained

$$Q = \frac{\pi}{4}\sqrt{\frac{g}{R^*}}\frac{1}{\sqrt{\lambda}}\sqrt{\frac{D^5}{LT}\left[p_1^2 - p_1^2 + \frac{2k}{3}(p_0^3 - p_1^3)\right]}$$

where R^* is the gas constant; $R^* = \frac{848}{m}$ metres; m is molecular weight; g is acceleration of gravity; p_0 is initial pressure; p_1 is counter-pressure; T is the absolute temperature of the gas; L is the length of the tube; Q is the weight rate of flow; λ is the coefficient of hydraulic resistance, determined from Nikuradze nets. For square law of resistance

$$\lambda = \frac{1}{\left(1.74 + 2\lg\frac{1}{\varepsilon}\right)^2}$$

where ε is relative roughness of the surface, $\varepsilon = 2e/D$; and e is absolute roughness.

The experiments that have been carried out up to this time, and investigations with a profile-measuring optical instrument, made at the Central Institute of Fluid Dynamics, Moscow, have shown that in gas pipes that have been at work for about one year, the average value of e ranges from 0.1 to 0.2 mm.

The above formula has been derived on the assumption that hydrocarbon gases depart considerably from Boyle's law, and for them the equation of state may be expressed in the form

$$p = \frac{\rho g}{1 + kp} R^* T$$

where ρ is the density of the gas, and k is a coefficient allowing for the departure of the gas from Boyle's law.

Received
12.VII.1945.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

GEODESY

ON THE APPLICATION OF CURVATURES

By V. A. KAZINSKY

(Communicated by O. J. Schmidt, Member of the Academy, 29. VIII. 1944)

1. The variometrical method of determining the component deflections of the plumb-line is based on the two following equations

$$\alpha = -\frac{T_x}{g}, \quad \beta = -\frac{T_y}{g} \tag{1}$$

where α and β are small angles of deflection (in radians) of the plumb-line in the planes x and y, directed northward and eastward, respectively; g is the acceleration of gravity at the point of determination of the derivatives T_x and T_y; T is the potential of the disturbing mass.

As follows from equations (1), the variometrical method will be of practical value as soon as a mathematical relation has been established between the derivatives T_x, T_y and the curvatures T_{xy}, T_Δ. The usual way to find this relation is by having recourse to geometry. Yet a simpler — analytical — method may also be recomended for this purpose.

From (1) find

$$\begin{aligned} d\alpha &= -\frac{1}{g}[T_{xy}\,dy + T_{xx}\,dx] \\ d\beta &= -\frac{1}{g}[T_{xy}\,dx + T_{yy}\,dy] \end{aligned} \tag{2}$$

Substituting $dx = dl\cos A$, $dy = dl\sin A$, and multiplying respectively by $\sin A$ and $\cos A$, write the difference between the above equations as follows

$$d\alpha \sin A - d\beta \cos A = -\frac{\overline{T}^{(1)}_{xy}}{g}\,dl \tag{3}$$

where A is the azimuth of the element dl, $T^{(1)}_{xy} = \frac{1}{2}T_\Delta \sin 2A + T_{xy}\cos 2A$.

To proceed to finite differences integrate equation (3) over the range from 0 to l. The result will be the well-known equation of Etwesh (1)

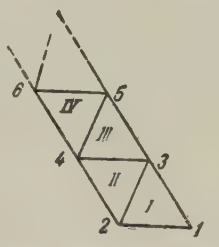
$$[\alpha \sin A - \beta \cos A]_0^l = -\frac{1}{g}\int_0^l T^{(1)}_{xy}\,dl \tag{4}$$

The analytical method of constructing the equation (4) does not remove the difficulties connected with the integration of the right-hand side of this equation. They consist essentially in the impossibility to represent the gravitational field by analytical functions. So one finds himself compelled

to assume that the variation of the derivatives $T_{xy}^{(l)}$ on passing from point to point through the distance l is linear, and to take accordingly that

$$N = \frac{1}{g}\int_0^l T_{xy}^{(l)} dl = \frac{T_{xy}^{(l)}}{g} l \qquad (5)$$

2. If the equations (4) and (5) are true for two variometric points separated by a distance l, they are true for a number of points arranged, say, in the form of an elongated variometric net composed of triangles. Numbering these points, as shown in the figure, we shall obtain a system of equations in the following form



$$(\alpha_{n+1} - \alpha_n)\sin A_{n+1,n} - (\beta_{n+1} - \beta_n)\cos A_{n+1,n} = -N_{n+1,n} \qquad (6)$$

By successively excluding one of the components, *e. g.* β, we obtain a new system of equations which contains the component α alone

$$\alpha_n = a_n'\alpha_{n+1} + b_n'\alpha_{n-1} + c_n' \qquad (7)$$

where

$$a_n' = \frac{\operatorname{tg} A_{n+1,n} - \operatorname{tg} A_{n+1,n-1}}{\operatorname{tg} A_{n+1,n} - \operatorname{tg} A_{n,n-1}}$$

$$b_n' = \frac{\operatorname{tg} A_{n+1,n-1} - \operatorname{tg} A_{n,n-1}}{\operatorname{tg} A_{n+1,n} - \operatorname{tg} A_{n,n-1}} \qquad (8)$$

$$c_n' = \frac{(N \sec A)_{n+1,n-1} - (N \sec A)_{n,n-1} - (N \sec A)_{n,n+1}}{\operatorname{tg} A_{n+1,n} - \operatorname{tg} A_{n,n-1}}$$

$$n = 2, 3, 4, \ldots \quad a_2' = a_2, \quad b_2' = b_2$$

Multiplying the first ($n=2$) equation of the system (7) by b_3' and adding it to the second ($n=3$), we obtain after some algebraic transformations

$$\alpha_3 = a_3\alpha_4 + b_3\alpha_1 + c_3 \qquad (9)$$

where a_3, b_3, c_3 have the following values:

$$a_3 = \frac{a_3'}{1 - a_2 b_3'}, \quad b_3 = \frac{b_2 b_3'}{1 - a_2 b_3'}, \quad c_3 = \frac{c_2 b_3' + c_3'}{1 - a_2 b_3'} \qquad (10)$$

Multiplying next (9) by b_4' and adding the result to the third equation of the system (7) we get

$$\alpha_4 = a_4\alpha_5 + b_5\alpha_1 + c_5 \qquad (11)$$

Proceeding further in this manner, we shall obtain a new system in place of (7), with the number of equations reduced by one

$$\alpha_n = a_n\alpha_{n+1} + b_n\alpha_1 + c_n \qquad (12)$$

Since

$$a_n + b_n = 1$$

we can also write it as follows

$$\alpha_n = a_n(\alpha_{n+1} - \alpha_1) + \alpha_1 + c_n \qquad (12')$$

where $n = 3, 4, 5, \ldots$.

We now have a system of equations for a relative evaluation of α, the component deflections of the plumb-line. This system, though simple, is not quite convenient for practical use. Its disadvantage lies mainly in the calculation of a, b and c which are functions linked by a rather cumbersome mathematical relation to a large number of arguments. However, we can make up for this deficiency by framing the computational process into schemes convenient for simple arithmetical operations. To put an example we shall take a case from actual practice, which will show the way in which the component deflections of the plumb-line are to be computed.

3. Scheme 1 contains all the necessary data for the calculation of the derivatives $T_{xy}^{(l)}$ and of the products $T_{xy}^{(l)} l$.

Scheme 1

Nos. of triangles	Side	Azimuth $A°$	T_Δ in 10^{-9} sec.$^{-2}$	sin 2A	T_{xy} in 10^{-9} sec.$^{-2}$	cos 2A	$T_{xy}^{(l)}$ in 10^{-9} sec.$^{-2}$	l in m	$T_{xy}^{(l)'} l$ in mgal
VII	8—7	280	−24	−0.34	−16	−0.94	+19	1250	+2.38
	6—7	340	−28	−0.64	−16	+0.77	−3	1000	−0.30
	6—8	58	−34	+0.90	−24	−0.44	−5	1000	−0.50
VIII	9—8	343	−28	−0.56	−26	+0.83	−14	1250	−1.75
	9—6	292	−30	−0.69	−22	−0.72	+26	1400	+3.64

Scheme 2 gives the order of construction of the initial equations (6) with the numerical values of $\sin A$, $\cos A$, and N.

Scheme 2

Nos. of triangles	Side	tg A	$(\alpha-\alpha)\sin A-(\beta-\beta)\cos A=-N$	$N \sec A$ and $\sum_1^3 (N \sec A)$
VII	8—7	−5.67	−( ) 0.98−( ) 0.17=+0.48	+2.82
	6—7	−0.36	−( ) 0.34−( ) 0.94=−0.06	−0.06
	6—8	+1.60	+( ) 0.85−( ) 0.53=−0.10	−0.19 −2.64
VIII	9—8	−0.31	−( ) 0.29−( ) 0.96=−0.35	−0.36
	9—6	−2.48	−( ) 0.93−( ) 0.36=+0.73	+1.39 −1.56

Scheme 3 gives the order of computation of the coefficients a and b and of c and α from the values of α_{n+1} and α_1, and from the data of scheme 2 (the computation is conducted from below upwards).

Scheme 3

Nos. of points	tg A − tg A			$\sum_1^3 N \sec A$	$\alpha_n=a'_n \alpha_{n+1}+b'_n \alpha_{n-1}+c'_n$			$1-a_{n-1} b'_n$	$\alpha_n=a_n \alpha_{n+1}+b_n \alpha_1+c_n$			
	$(n+1, n)-(n+1, n-1)$	$(n+1, n)-(n, n-1)$	$(n+1, n-1)-(n, n-1)$		a'_n	b'_n	c'_n		a_n	b_n	c_n	α''
7	—	—	—	—	—	—	—	—	—	—	—	−3.6
8	+1.96	+7.27	+5.31	−2.69	+0.27	+0.73	−0.33	—	—	—	—	−4.0
6	−1.17	−4.08	−1.91	−2.09	+0.53	+0.47	+0.38	+0.87	+0.61	+0.39	+0.24	−4.2
9	+1.87	+4.21	+2.34	−2.07	+0.44	+0.56	−0.37	+0.66	+0.67	+0.33	−0.36	−4.7

4. From the values of α thus established the components β can be found. For this purpose we must turn to the initial equations (6), and the results of the calculations should again be set out in tabular form according to scheme 2. Since each of the β-components is twice computed by means of these equations, the ultimate value is determined as a weight average from the formula

$$\beta = \frac{\beta_1 \cos A_1 + \beta_2 \cos A_2}{\cos A_1 + \cos A_2} \tag{13}$$

where $\cos A_1$ and $\cos A_2$ are measures of the accuracy with which β_1 and β_2 have been determined.

Institute of Theoretical Geophysics.
Academy of Sciences of the USSR.

Received
29.VIII.1944.

REFERENCES

[1] Р. Этвеш, Исследование о поверхностях уровня, Сб. рефератов и статей, Прилож. к запискам Военно-топогр. отд., 1910.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

MATHEMATICAL PHYSICS

ON DIFFRACTION OF ELASTIC WAVES

By D. I. SCHERMAN

(Communicated by I. M. Vinogradov, Member of the Academy, 7. VI. 1945)

Suppose an elastic medium to fill a finite simply connected region S bounded by a closed curve L. The course of L is defined to be counter-clockwise, and for the positive sense of a normal n to L we take the direction from inside of S to the outside. Furthermore, the coordinates of the points of L, $x(s)$ and $y(s)$, are assumed to be differentiable with respect to arc s a sufficient number of times.

As is well known, the components of the translation vector along the x and y axes, $u_1(x, y, t)$ and $v_1(x, y, t)$, can be expressed through the longitudinal and transverse potentials $\varphi_1(x, y, t)$ and $\psi_1(x, y, t)$ by means of the formulae

$$u_1 = \frac{\partial \varphi_1}{\partial x} + \frac{\partial \psi_1}{\partial y}; \quad v_1 = \frac{\partial \varphi_1}{\partial y} - \frac{\partial \psi_1}{\partial x} \tag{1}$$

These potentials satisfy the so-called wave equations

$$\Delta \varphi_1 = \frac{1}{a^2} \frac{\partial^2 \varphi_1}{\partial t^2}, \qquad \Delta \psi_1 = \frac{1}{b^2} \frac{\partial^2 \psi_1}{\partial t^2} \tag{2}$$

in which Δ is Laplace's operator, a and b are propagation velocities of longitudinal and transverse waves, respectively

$$a = \sqrt{\frac{\lambda + 2\mu}{\rho}}; \quad b = \sqrt{\frac{\mu}{\rho}} \tag{3}$$

where ρ is the density of the medium, and λ, μ are Lamé constants.

In the case of steady vibrations we have

$$\begin{aligned} \varphi_1(x, y, t) &= \varphi(x, y)\, e^{ipt}, \quad \psi_1(x, y, t) = \psi(x, y)\, e^{ipt} \\ u_1(x, y, t) &= u(x, y)\, e^{ipt}, \quad v_1(x, y, t) = v(x, y)\, e^{ipt} \end{aligned} \tag{4}$$

where p is vibration frequency, and φ, ψ and u, v depend solely on the variables x and y. We then have

$$u = \frac{\partial \varphi}{\partial x} + \frac{\partial \psi}{\partial y}, \qquad v = \frac{\partial \varphi}{\partial y} - \frac{\partial \psi}{\partial x} \tag{5}$$

$$\Delta \varphi + k_1^2 \varphi = 0, \ \Delta \psi + k_2^2 \psi = 0, \quad k_1 = p \sqrt{\frac{\rho}{\lambda + 2\mu}}; \quad k_2 = p \sqrt{\frac{\rho}{\mu}} \tag{6}$$

One of the main problems of the theory of elasticity with regard to steady vibrations is to determine the components of the translation vector

in the region S from their values at the boundary. This problem reduces to the integration of equations (6) under the following condition at L

$$\frac{\partial\varphi}{\partial x}+\frac{\partial\psi}{\partial y}=f_1(s), \quad \frac{\partial\varphi}{\partial y}-\frac{\partial\psi}{\partial x}=f_2(s) \tag{7}$$

where $f_1(s)$ and $f_2(s)$ are some known continuous functions of arc s.

We shall presently show that this problem can be reduced directly to a Fredholm's system of integral equations *.

We set out to find the longitudinal and transverse potentials in the form

$$\begin{aligned}\varphi(x, y)&=\int_L \{\nu_1(s)\,F_1^{(1)}(x, y; s)+\nu_2(s)\,F_2^{(1)}(x, y; s)\}\,ds,\\ \psi(x, y)&=\int_L \{\nu_1(s)\,F_1^{(2)}(x, y; s)+\nu_2(s)\,F_2^{(2)}(x, y; s)\}\,ds\end{aligned} \tag{8}$$

where $\nu_j(s)$ $(j=1, 2)$ are now unknown functions (s is the arc of a point $M(\xi, \eta)$ lying on L), and

$$\begin{aligned}F_1^{(1)}&=A\frac{\partial}{\partial x}\frac{dH_0^{(2)}(k_1r)}{dn}+B\cos(n, \xi)\,H_0^{(2)}(k_1r)\\ F_2^{(1)}&=A\frac{\partial}{\partial y}\frac{dH_0^{(2)}(k_1r)}{dn}+B\cos(n, \eta)\,H_0^{(2)}(k_1r)\\ F_1^{(2)}&=A\frac{\partial}{\partial y}\frac{dH_0^{(2)}(k_1r)}{dn}+C\cos(n, \eta)\,H_0^{(2)}(k_2r)\\ F_2^{(2)}&=-A\frac{\partial}{\partial x}\frac{dH_0^{(2)}(k_2r)}{dn}-C\cos(n, \xi)\,H_0^{(2)}(k_2r)\end{aligned} \tag{9}$$

Here $H_0^{(2)}$ is Hankel's second function; $r=\sqrt{(x-\xi)^2+(y-\eta)^2}$, and A, B, C are constants expressed as follows

$$A=-\frac{i}{(k_1^2+k_2^2)}, \quad B=\frac{i(k_1^2-k_2^2)}{2(k_1^2+k_2^2)}, \quad C=-\frac{i(k_1^2-k_2^2)}{2(k_1^2+k_2^2)}. \tag{10}$$

Put

$$\begin{aligned}H_0^{(2)}(k_j r)&=-\frac{2i}{\pi}\ln r+P(k_jr).\\ H_0^{(2)}(k_jr)&=-\frac{2i}{\pi}\left(1-\frac{k_j^2r^2}{4}\right)\ln r+Q(k_jr)\quad (j=1, 2)\end{aligned} \tag{11}$$

where the functions $P(k_jr)$ obviously have partial derivatives of the first order with respet to x and y, and $Q(k_jr)$ have partial derivatives of the third order (with respect to the same variables) continuous within S and at the points of L.

Upon computing, according to formulae (8), the first partial derivatives of the functions $\varphi(x, y)$ and $\psi(x, y)$, and composing the expressions $\partial\varphi/\partial x+\partial\psi/\partial y$, $\partial\varphi/\partial y-\partial\psi/\partial x$ we proceed in them to the limit, making $M(x, y)$ tend to a certain point $M(\xi_0, \eta_0)$ of the contour L. Afterwards performing certain

---

* The problem was also dealt with by Kupradze [1]. He treated the sought-for functions $\varphi(x, y)$ and $\psi(x, y)$ as potentials of a simple layer, and in determining the densities at first obtained a system of singular integral equations, and transformed it then by regulation to a Fredholm's system which we give here.

transformations and taking the condition (7) into account, we shall obtain, for determining $\nu_j(s)$ $(j=1, 2)$, a Fredholm's system of equations

$$\begin{aligned}
&\nu_1(s_0)+\int_L\left\{\nu_1(s)\,K_1^{(1)}(s, s_0)+\nu_2(s)\,K^{(1)}(s, s_0)\right\}ds=f_1(s_0)\\
&\nu_2(s_0)+\int_L\{\nu_1(s)\,K_1^{(2)}(s, s_0)\nu+{}_2(s)\,K_2^{(2)}(s, s_0)\}\,ds=f_2(s_0)
\end{aligned}\tag{12}$$

with continuous kernels

$$\begin{aligned}
K_1^{(1)}(s, s_0)&=\frac{1}{\pi}\,\frac{d\ln r_0}{dn}+\frac{1}{\pi(k_1^2+k_2^2)}\left[k_1^2\left\{1-2\left(\frac{\partial r_0}{\partial\xi}\right)^2\right\}+\right.\\
&\left.+k_2^2\left\{1-2\left(\frac{\partial r_0}{\partial\eta}\right)^2\right\}\right]\frac{d\ln r_0}{dn}+\frac{\partial R_1^{(1)}}{\partial\xi_0}+\frac{\partial R_1^{(2)}}{\partial\eta_0}\\
K_2^{(1)}(s, s_0)&=-\frac{2}{\pi}\,\frac{(k_1^2-k_2^2)}{(k_1^2+k_2^2)}\,\frac{\partial r_0}{\partial\xi}\,\frac{\partial r_0}{\partial\eta}\,\frac{d\ln r_0}{dn}+\frac{\partial R_2^{(1)}}{\partial\xi_0}+\frac{\partial R_2^{(2)}}{\partial\eta_0}\\
K_1^{(2)}(s, s_0)&=-\frac{2}{\pi}\,\frac{(k_1^2-k^2)}{(k_1^2+k_2^2)}\,\frac{\partial r_0}{\partial\xi}\,\frac{\partial r_0}{\partial\eta}\,\frac{d\ln r_0}{dn}+\frac{\partial R_1^{(1)}}{\partial\eta_0}-\frac{\partial R_1^{(2)}}{\partial\xi_0}\\
K_2^{(2)}(s, s_0)&=\frac{1}{\pi}\,\frac{d\ln r_0}{dn}+\frac{1}{\pi(k_1^2+k_2^2)}\left[k_1^2\left\{1-2\left(\frac{\partial r_0}{\partial\eta}\right)^2\right\}+\right.\\
&\left.+k_2^2\left\{1-2\left(\frac{\partial r_0}{\partial\xi}\right)^2\right\}\right]\frac{d\ln r_0}{dn}+\frac{\partial R_2^{(1)}}{\partial\eta_0}-\frac{\partial R_2^{(2)}}{\partial\xi_0}
\end{aligned}\tag{13}$$

where $r_0=\sqrt{(\xi-\xi_0)^2+(\eta-\eta_0)^2}$ and

$$\begin{aligned}
R_1^{(1)}(x, y; s)&=A\frac{\partial}{\partial x}\,\frac{dQ(k_1r)}{dn}+B\cos(n, \xi)\,P(k_1r)\\
R_2^{(1)}(x, y; s)&=A\frac{\partial}{\partial y}\,\frac{dQ(k_1r)}{dn}+B\cos(n, \eta)\,P(k_1r)\\
R_1^{(2)}(x, y; s)&=A\frac{\partial}{\partial y}\,\frac{dQ(k_2r)}{dn}+C\cos(n, \eta)\,P(k_2r)\\
R_2^{(2)}(x, y; s)&=-A\frac{\partial}{\partial x}\,\frac{dQ(k_2r)}{dn}-C\cos(n, \xi)\,P(k_2r)
\end{aligned}\tag{14}$$

If the system (12) is solvable, then, determining $\nu_j(s)$ $(j=1, 2)$ from it, we can find the required solution by means of formulae (8)*.

In considering the properties of the kernels of system (12) one has to take account (see, *e. g.* [2]) of the equalities

$$\begin{aligned}
\lim_{M(x, y)\to M(\xi_0, \eta_0)}I_1&=\lim_{M(x, y)\to M(\xi_0, \eta_0)}\frac{1}{\pi}\int_L\nu(s)\left(\frac{\partial r}{\partial\xi}\right)^2\frac{d\ln r}{dn}\,ds=\\
&=\frac{\nu(s_0)}{2}+\frac{1}{\pi}\int_L\nu(s)\left(\frac{\partial r_0}{\partial\xi}\right)^2\frac{d\ln r_0}{dn}\,ds,\\
\lim_{M(x, y)\to M(\xi_0, \eta_0)}I_2&=\lim_{M(x, y)\to M(\xi_0, \eta_0)}\frac{1}{\pi}\int_L\nu(s)\,\frac{\partial r}{\partial\xi}\,\frac{\partial r}{\partial\eta}\,\frac{d\ln r}{dn}\,ds=\\
&=\frac{1}{\pi}\int_L\nu(s)\,\frac{\partial r_0}{\partial\xi}\,\frac{\partial r_0}{\partial\eta}\,\frac{d\ln r_0}{dn}\,ds.
\end{aligned}$$

---

* Note that to the right-hand sides of (8) we can add any operator (dependent on $\nu_j(s)$ $(j=1,2)$, such as would satisfy the respective equations (6) and remain continuous, together with their first derivatives, as the point $M(x, y)$ crosses the boundary L. Such modification of the formulae (8) may prove to be useful in facilitating the investigation of the corresponding system (12).

They can be easily verified. Putting, indeed, $t=\xi+i\eta$, we after simple transformations find

$$I_1=\frac{1}{4\pi i}\int_L \nu(z)\left\{\frac{dt}{t-z}-\frac{\overline{dt}}{\overline{t}-\overline{z}}\right\}-\frac{1}{8\pi i}\int_L \nu'(s)\left\{\frac{t-z}{\overline{t}-\overline{z}}-\frac{\overline{t}-\overline{z}}{t-z}\right\}ds,$$

$$I_2=\frac{1}{8\pi}\int_L \nu'(s)\left\{\frac{t-z}{\overline{t}-\overline{z}}+\frac{\overline{t}-\overline{z}}{t-z}\right\}ds$$

from which follows the result required.

Proceeding from the same formulae (8), the problem under consideration can be reduced to a Fredholm system of equations in the case of an infinite region as well. Apparently, the so-called Sommerfeld principle of radiation will then take place.

Institute of Mechanics.
Academy of Sciences of the USSR.

Received
7.VI.1945.

REFERENCES

[1] В. Д. Купрадзе, Основные задачи математической теории дифракции, 1935.
[2] G. Lauricella, Acta Math., 32, 201 (1909).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

PHYSICS

PROPAGATION OF WAVES AND RETARDATION OF ELECTRON BEAMS IN PLASMA

By E. ADIROVICH

(Communicated by S. I. Vavilov, Member of the Academy, 25. X. 1944)

1. In a previous paper [1] the author has given a solution for the problem of those processes in plasma which can be expressed by a kinetic equation without taking into account collisions. In this paper we shall consider the

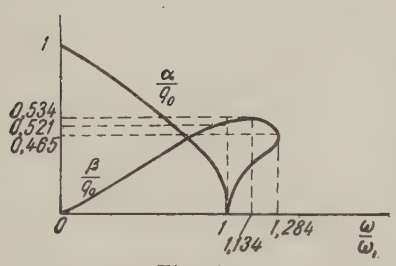


Fig. 1

$\tilde{q}_1 = \frac{\alpha}{q_D}$, $\tilde{q}_2 = \frac{i\beta}{q_D}$, $\tilde{k} = \frac{i\omega}{\omega_L}$

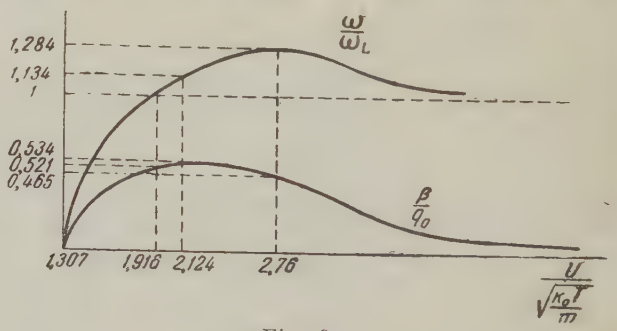


Fig. 2

$\tilde{q} = \frac{i\beta}{q_D}$, $\tilde{k} = \frac{i\omega}{\omega_L}$

propagation of waves and the retardation of electron beams in plasma as described on the basis of the solutions found

$$\Phi(x, u, v, w, t) = A \frac{ue^{\frac{m(u^2+v^2+w^2)}{2k_0T}}}{u - \frac{k}{q}} e^{qx-kt} \tag{1}$$

$$\Delta n(x, t) = Cq^2 e^{qx-kt} \tag{2}$$

$$S(x, t) = Cqke^{qx-kt} \tag{3}$$

2. Formulae (1), (2), (3) describe the oscillation processes which take place in plasma for the case where $k = i\omega$. Fig. 1 shows the dependence of the spatial structure, the excess density $\Delta n(x, t)$ and the electron flow $S(x, t)$, upon the frequency of the process. Fig. 2 shows the dependence of the phase velocity of the waves $v = \omega/\beta$ upon the frequency ω and the wave number β.

According to Fig. 1, the spectrum of the plasma's own frequencies is a l and $0 < \omega \leqslant 1.284\,\omega_L$. Each frequency has two solutions corresponding to it.

When $\omega < \omega_L$, one of them represents the variable surface polarization of the plasma

$$\Delta n_1(x, t) = C_1 \alpha^2 e^{\alpha x - i\omega t} \tag{4}$$

and the other, the wave

$$\Delta n_2(x, t) = C_1 \beta^2 e^{i(\omega t - \beta x)} \tag{5}$$

With $\omega > \omega_L$ both solutions are of the wave type (5). Therefore, propagation of waves not only with greater, but also with smaller frequencies than the Langmuir frequency is possible in the plasma.

There are two types of long waves ($\beta = 2\pi/\lambda \to 0$) in plasma. One of them corresponds to infinitely small frequencies $\lim_{\beta \to 0} \omega = 0$. The frequencies of the second type of waves remain finite and have as their limit the Langmuir frequency. According to Fig. 2, the limit value of the phase velocity of waves of the first type (acoustic waves) with $\omega \to 0$ equals $v = 1.307 \sqrt{k_0 T/m}$. This is the adiabatic velocity of «sound» in electronic plasma. Knowing it, we can determine the isobaric heat capacity of electronic plasma

$$\frac{c_p - c_p \text{ id.gas}}{c_v} = 1.307^2 - 2.667 = 0.041; \quad c_p = \frac{5.123}{2} k_0 \tag{6}$$

Under actual discharge conditions very slow acoustic waves are greatly distorted by damping due to collisions which cannot be neglected when their frequencies are of the same order as those of the oscillation. However, as soon as $\omega/\omega_L \sim 0.01$, the model already corresponds to real plasma, since

$$\omega_{\text{coll}} \sim 10^4 \text{ sec.}, \quad \omega_L \sim 10^9 \text{sec.}^{-1} \tag{7}$$

Solving with respect to ω^2 the approximative expression for the section of the dispersion curve which corresponds to the second branch of long waves

$$\frac{\beta^2}{q_D^2} = \frac{\omega^2}{\omega_L^2} - 1 \tag{8}$$

([1]), Table 1, line 3) we get

$$\omega^2 = \frac{4\pi n e^2}{m} + \frac{k_0 T}{m} \frac{4\pi^2}{\lambda} \tag{9}$$

— Linder's, dispersion formula ([2]), formula (7)). This branch (Linder's wave) represents the waves into which the surface polarization of the plasma is transformed when the frequency exceeds the value $\omega = \omega_L$. The physical sense of such transformation with $\omega = \omega_L$ becomes obvious if (9) is written in another form. Multiplying (8) by ω_L^2/ω^2 and noting that $\omega_L^2/q_D^2 = k_0 T/m = v_T^2$, and that $\omega^2/\beta^2 = v^2$, we get

$$n_0^2 = \frac{v_T^2}{v^2} = 1 - \frac{\omega_L^2}{\omega} = 1 - \frac{4\pi n e^2}{m\omega^2} \tag{10}$$

With $\omega < \omega_L$ the polarization $\vec{P}$ in the expression

$$\vec{D} = \vec{E} + 4\pi\vec{P} = (1 + 4\pi\gamma)\vec{E} = n_0^2 \vec{E} \tag{11}$$

has a direction opposite to $\vec{D}$ and screens the penetration of the field into the plasma ($n_0^2 < 0$). As ω increases, the inertia of the electrons becomes of greater and greater importance; the depth of penetration of the field $1/\alpha$ increases (Fig. 1). With $\omega \geq \omega_L$ the oscillations of the electrons are no longer in phase with the field. There appears a phase difference, and the wave begins to penetrate into the plasma ($n_0^2 > 0$). In Fig. 2 the extreme right-hand section of the curve $v(\omega)$ corresponds to Linder's waves ($v \to \infty$, $d\omega/d\beta \to 0$).

The upper branch of the curve $\beta(\omega)$ (Fig. 1) and also that part of the lower branch which does not come into immediate contact with $\omega = \omega_L$ corresponds to short waves with $\lambda = 2\pi/\beta \cong 0.2 - 20$ cm if $n \sim 10^{10}$ el/cm^3, $T \sim 10^5$ °K.

3. When $k = \varkappa$ the density and the flux

$$\Delta n(x, t) = C\alpha^2 e^{\alpha x - \varkappa t} \tag{12}$$

$$S(x, t) = C\alpha\varkappa e^{\alpha x - \varkappa t} \tag{13}$$

relax. The relaxation solutions show the disappearance of an electron beam thrown into the plasma, as a result of its Coulomb forces retarding the

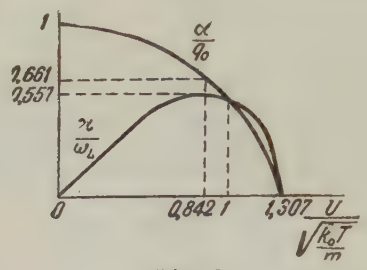


Fig. 3

$$\tilde{q} = \frac{\alpha}{q_D}, \quad \tilde{k} = \frac{\varkappa}{\omega_L}$$

three-dimensional charges in the plasma. According to (12) and (13) the average velocity of electrons

$$\bar{u} = \frac{S}{\Delta n} = \frac{\varkappa}{\alpha} = v \tag{14}$$

The curves in Fig. 3 show the dependence of the time and of the lenght of relaxation upon the velocity of the beam*

$$\tau = 1/\varkappa, \quad L = 1/\alpha \tag{15}$$

Fig. 2 (see [1]) shows the relation between τ and L; along the axes are plotted the inverse values $\varkappa = 1/\tau$ in units ω_L, and $\alpha = 1/L$ in units q_D.

With the exception of the low values of v close to $v/\sqrt{k_0 T/m} = 0$ and $v/\sqrt{k_0 T/m} = 1.307$ ($\Delta v/\sqrt{k_0 T/m} \sim 0.01$) with which the relaxation times become commensurable with the times of free run of the electrons, making it impossible to neglect the collisions, the orders of the values τ and L are equal to

$$\tau = \frac{1}{\varkappa} \sim \frac{10}{\omega_L} = 10\sqrt{\frac{m}{4\pi n e^2}} \sim 2.10^{-9} \text{ sec.} \tag{16}$$

$$L = \frac{1}{\alpha} \sim \frac{10}{q_D} = 10\sqrt{\frac{k_0 T}{4\pi n e^2}} \sim 0.2 - 0.02 \text{ cm} \tag{17}$$

(with $n \sim 10^{10}$ el/cm^3 and $T \sim 10^5$ °K). The relaxation length of values obtained by the theory expounded here, which is based on the conception of the retardation of the beam by the macroscopic fields of volume charges, are in much better conformance with experimental data than those computed from the scheme of collisions or retardation on microfields ([3]).

With $v \to 1.307\sqrt{k_0 T/m}$ the times and lengths of relaxation become infinite. This is due to the fact that the «tranquil» retardation of

* The length of relaxation is the distance run by the electrons of a beam during the relaxation time of the latter

$$L = 1/\alpha = v/\varkappa = v\tau$$

the beam by plasma considered here takes place only when the velocity of the beam is less than the adiabatic velocity of «sound» in the plasma (the limitedness of the complete set of values for v in Fig. 3). When $v = 1.307\sqrt{k_0T/m}$ the mechanism of retardation of the beam changes abruptly, and when $v > 1.307\sqrt{k_0T/m}$ it is connected with excitation of the outgoing waves of electronic density in plasma (see Fig. 2, according to which $v = 1.307 \times \times\sqrt{kT_0/m}$ is the minimum phase velocity of the electronic density waves in the plasma). In order to find the solutions of the basic equation ([1], formula (1)), which describe these processes, the dispersion equation must be solved for complex values of k and q.

«Tranquil» retardation can take place with velocity values $v < 1.307 \times \times\sqrt{k_0T/m} \cong 2 \cdot 10^8$ cm/sec. ~ 10 volts ($n \sim 10^{10}$ el/cm^3, $T \sim 10^5$ ° K), *i. e.* for fairly slow beams.

Received
25.X.1944.

REFERENCES

[1] E. Adirovich, C. R. Acad. Sci. URSS, XLVIII, No. 8 (1945). [2] E. Linder, Phys. Rev., **49**, No. 10, 753 (1936). [3] R. Rompe u. M. Steenbeck, Erg. d. exact. Naturwiss., **18**, 257 (1939). [4] Э. Адирович, Кандидатская диссертация, НИИФ. МГУ, 1944.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

PHYSICS

DEPENDENCE OF THE DIELECTRIC CONSTANT OF BARIUM TITANATE UPON THE PRESSURE

By B. M. WUL, Corresponding Member of the Academy, and L. F. VERESHCHAGIN

The change in the dielectric constant of a substance as a function of the external pressure has been studied until now only for gases and liquids (1).

For a qualitative estimation of the dependence of the dielectric permeability upon the pressure we proceed from the fact that

$$\varepsilon = 1 + \frac{4\pi n\alpha}{1 - \gamma n\alpha} \tag{1}$$

where ε is the dielectric constant, n is the number of particles in unit volume, α is the polarizability of a particle, and γ is the internal field constant (2).

Assuming that the temperature remains constant (α and n depend only upon the pressure) and that the internal field constant γ does not change in the investigated pressure range, we find that

$$\frac{d\varepsilon}{dp} = \frac{\partial\varepsilon}{\partial n}\frac{dn}{dp} + \frac{\partial\varepsilon}{\partial\alpha}\frac{d\alpha}{dp} \tag{2}$$

Since the number of particles in unit volume $n = N/v$, where N is the Loshmidt number and v is the volume occupied by a gram molecule, then

$$\frac{dn}{dp} = -\frac{N}{v^2}\frac{dv}{dp} = nk$$

where $k = -\frac{1}{v}\frac{dv}{dp}$ is, by definition, the coefficient of compression. Determining from equation (1) $\partial\varepsilon/\partial n$ and $\partial\varepsilon/\partial\alpha$ and substituting these values, as well as the value for dn/dp, into equation (2), we find that

$$d\varepsilon = (\varepsilon - 1)\left[1 + \frac{(\varepsilon - 1)\gamma}{4\pi}\right]\left(k + \frac{1}{\alpha}\frac{d\alpha}{dp}\right)dp \tag{3}$$

In solids the coefficient of compression is very small, of the order of 10^{-6} cm^2/kg. Therefore, in order that the change in ε with pressure be detectable, it is necessary that ε, or $\frac{1}{\alpha}\frac{d\alpha}{dp}$, or both be great.

As was recently established, barium titanate has a dielectric permeability exceeding 1000, *i. e.* tens of time greater that displayed by ordinary materials, and markedly dependent upon the temperature (3). Hence it was to be expected that it would be possible to detect the effect of the change in the dielectric constant as a function of the pressure in this material.

The measurements were carried out on a specimen with silver electrodes obtained by burning the silver into the material at a temperature of about 750° C. The capacity of the sample was measured at a frequency of about 10^6 cycles by the pulsation method with the aid of a dielcometer, which made it possible to measure the change in capacity with a precision of up to 0.03—0.05 cm.

The measurements were carried out in a steel cylinder diagrammatically shown in Fig. 1. As can be seen from the figure, the steel cylinder was provided with a lead-in *b* at the lower end of which the specimen *a* was mounted ([4]).

To the specimen was sealed a copper-constantan thermocouple, introduced into the steel cylinder with the aid of a second electric lead-in *c*. To obviate sharp fluctuations in temperature with a rise in pressure, during measurements the specimen in the cylinder was enclosed in a thick-walled brass block. The pressure inside the steel cylinder was built up with the aid of a hydraulic compressor ([5]). The oil from the hydraulic compressor was introduced through a steel capillary and nipple inside the cylinder, and the value of the pressure attained was read with the aid of a pointer manometer *d*. The temperature of the sample during measurements was controlled with the aid of a thermocouple and a mirror galvanometer.

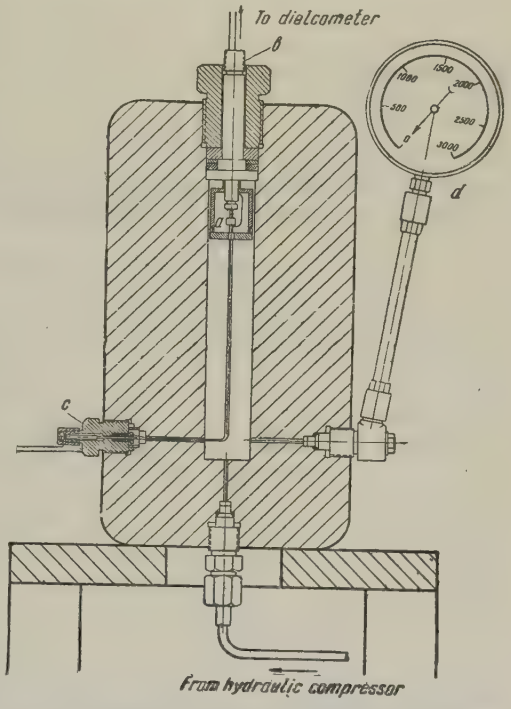


Fig. 1. General view of the steel cylinder for measuring the dielectric constant under pressure

Preliminary measurements carried out while varying the pressure throughout the range investigated, but without the condensor of barium titanate, showed that the changes in the capacity of the electric lead-in are so small in comparison with the effect under observation that they meight be disregarded. Preliminary measurements under a pressure of up to 2000 atm. were also carried out with a tubular ceramic condensor made of a titanate magnesia material ([6]). No changes in capacity of the condensor were detectable with our apparatus.

The results of measurements with a condensor of barium titanate are given in Fig. 2. All measurements of the capacity under pressure were begun only from 300 atm. in order to avoid leaving bubbles of air in the electric lead-in and the system, which might have resulted in poor reproducibility of results.

As can be seen from the data given in Fig. 2, the capacity of the condensor increases with pressure at an ever diminishing rate. The mean relative change in capacity in the pressure range from 300 to 2000 atm. is

$$\frac{1}{C}\frac{\Delta C}{\Delta p} = 1.2 \cdot 10^{-5} \text{ cm}^2/\text{kg}.$$

As the capacity $C = \varepsilon S/4\pi d$, where S is the surface and d is the thickness of the sample, therefore

$$\frac{1}{\varepsilon}\frac{d\varepsilon}{dp} = \frac{1}{C}\frac{dC}{dp} + \frac{k}{3}$$

when the indicated method of plating the electrodes is used. If for barium

titanate k is of the same order of magnitude as for other solids, it may be assumed that $\frac{1}{\varepsilon}\frac{d\varepsilon}{dp} \cong \frac{1}{C}\frac{dC}{dp}$.

Assuming that $\varepsilon\nu/4\pi \gg 1$ (since $\varepsilon \gg 1$), we find from equation (3) that

$$\frac{d\varepsilon}{\varepsilon^2} \cong \frac{\nu}{4\pi}\left(k + \frac{1}{\alpha}\frac{d\alpha}{dp}\right)dp$$

If we assume that in the investigated pressure range

$$\frac{\nu}{4\pi}\left(k + \frac{1}{\alpha}\frac{d\alpha}{dp}\right) = b$$

and does not depend upon the pressure, then

$$\frac{d\varepsilon}{\varepsilon^2} = dp \quad \text{and} \quad \frac{1}{\varepsilon} = \frac{1}{\varepsilon_0} - b(p - p_0)$$

where ε_0 is dielectric constant at a pressure p_0. In Fig. 2 the black squares represent the values of $1/C$, the inverse of the capacity.

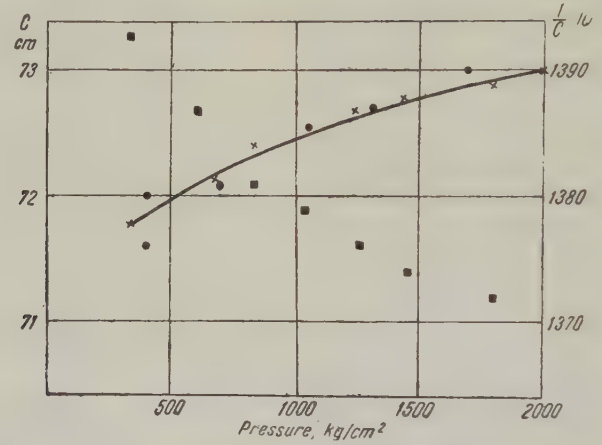


Fig. 2. Dependence of the dielectric constant upon the pressure for barium titanate

It is possible that above the range we investigated a change in pressure may noticeably affect the polarizability. It is not excluded, for example, that a decrease in ionic polarizability with an increase in pressure may lead to a decrease in $\frac{1}{\alpha}\frac{d\alpha}{dp}$ and at a sufficiently great pressure to a change in the sign of $d\varepsilon/dp$. After this work was completed, one of the authors discovered in barium titanate a dielectric hysteresis, which proves in addition to other data obtained previously, barium titanate to be a new segnetoelectric.

This research is now being extended to include measurements of the dielectric constant at higher pressures and at different temperatures.

The P. N. Lebedev Institute of Physics.
Academy of Sciences of the USSR,
and The Institute of Organic Chemistry.
Academy of Sciences of the USSR.

Received
27.VII.1945.

REFERENCES

[1] W. Danforth, Phys. Rev. (2), **38**, 1224 (1931). [2] П. Дебай и Г. Зак, Теория электрических свойств молекул, 1936. [3] B. M. Wul and I. M. Goldman, C. R. Acad. Sci. URSS, XLVI, 139 (1945). [4] Б. С. Александров и Л. Ф. Верещагин, ЖТФ, IX, в. 6 (1939). [5] L. F. Vereshchagin and N. D. Zelinsky, Bull. Acad. Sci. URSS, sér. chim., No. 6 (1943). [6] B. M. Wul and G. I. Skanavi, Bull. Acad. Sci. URSS, sér. phys., **8**, 194 (1944).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

BIOPHYSICS

SPECTRUM SENSITIVITY OF THE THREE RECEPTORS OF THE EYE

By M. M. GUREWITSCH

(Communicated by S. I. Vavilov, Member of the Academy, 18. XI. 1944)

1. A brief account of a report by D. B. Judd was reviewed in the Journal of the American Optical Society for June, 1943 (1); this writer suggests to replace the International mixture curves by such curves as would permit to evaluate the properties of colour vision in protanopes and deuteronopes. The problems aroused in this report seem to us to deserve ampler discussion, for their more meticulous analysis may be helpful in forming an idea of the possible nature of the sensivity of the three real eye receptors to the different parts of the spectrum.

During a long period of time one of the fundamental tasks of physiological optics and colorimetry was to plot mixture curves for the average eye. The advances made in this domain are associated with the names of König and Dieterici (2), Abney (3), Wright (4) and Guild (5). The results obtained by the two last authors have been laid at the basis of the international standards for the evaluation of colour perception by the average observer.

2. The only method permitting to approach the problem of primary physiological colours is the one based upon the study of the vision of colour-blind observers. It has been observed as far back as by Young (6) that the peculiarities which distinguish the vision of dichromates must most probably be accounted for by the deficiency (paralysis) of one of the three normally functioning eye receptors. On this account Maxwell (7) has found that dichromates must identify such colours as are distinctly discriminated by normal observers; in the usual chromaticity diagram the corresponding hues should, therefore, fit within straight lines converging to one point (see also Helmholtz (8)). The position of this point determines the chromaticity of the fundamental colour which is not perceived by the dichromate tested.

The realization of the experiment which had been conceived so many years ago involved considerable difficulties, and it was not before 1935 that Pitt (9) succeeded in obtaining satisfactory results. According to Judd (10), in the case of protanopia the point of intersection has the coordinates $x_1=0.747$; $y_1=0.253$; while in the case of deuteronopia they are $x_2=1.000$; $y_2=0.000$.

The extreme rarity of tritanopia cases prevented analogous experiments on the third possible subtype of dichromatism from being carried out. It may, however, be assumed that, like the chromaticity of the red receptor, the chromaticity of the violet one must be located near the opposite end of the curve of spectral colours; in this case it should be attributed to coefficients x_3 and y_3 equal to 0.180 and 0.000, respectively.

Let us select as primary such colours whose chromaticity is determined by three points plotted beforehand. Denote them by R, G and V, respectively (Red, Green and Violet) and express them through X, Y and Z, in relations that would make their mixture in equal proportions possess a chromaticity of the equal-energy

white ($x=y=0.333$). After rather simple computations we obtain

$$\left.\begin{aligned} \text{Red} &= 2.9526\,X + 1.000\,Y + 0.000\,Z \\ \text{Ggeen} &= -2.1721\,X + 0.000\,Y + 0.000\,Z \\ \text{Violet} &= 0.2195\,X + 0.000\,Y + 1.000\,Z \end{aligned}\right\} \quad (1)$$

It is easy to see that

$$R+G+V=X+Y+Z \quad (2)$$

As may be seen from equations (1), the luminosity coefficients L_R, L_G and L_V of the primary colours introduced by us are equal to 1, 0 and 0, respectively.

The coordinates x', y', z' and r', g', v' of the arbitrary colour F in the system X, Y, Z and R, G, V are connected by the relations

$$\left.\begin{aligned} r' &= y' \\ g' &= -0.4604\,x' + 1.3593\,y' + 0.1011z' \\ v' &= z' \end{aligned}\right\} \quad (3)$$

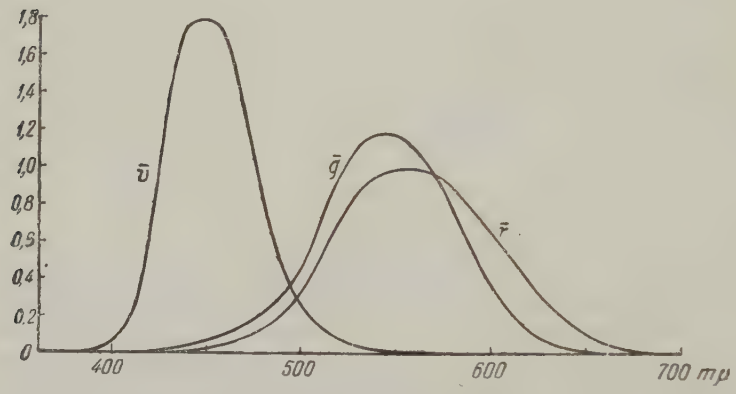


Fig. 1. Mixture curves for $\bar{r}$, $\bar{g}$, $\bar{v}$, referred to primary colours Red, Green and Violet

The coordinates $\bar{x}$, $\bar{y}$, $\bar{z}$ and $\bar{r}$, $\bar{g}$, $\bar{v}$ of the equal-energy monochromatic radiations are connected by the same relations (3). The table contains the values of $\bar{r}$, $\bar{g}$, $\bar{v}$, the ordinates of the mixture curves for the primary colours R, G and V (Fig. 1), as well as the values of the corresponding trichromatic coefficients of r, g and v.

3. The spectral curve expressing the sensitivity of the «red» receptor $\bar{r}$ coincides with the spectral sensitivity curve of an average eye. The curve for $\bar{v}$ does not differ from the international $\bar{z}$ curve. The greatest interest attaches to the $\bar{g}$ curve, which replaces the $\bar{x}$ curve of the international system. Unlike the latter, it shows no second maximum, which seems rather probable for a curve of sensitivity of a real receptor.

As has been demonstrated by Judd ([10]), a curve which does practically fit in with the $\bar{g}$ curve, is also in fair agreement with the curve plotted for the protanopic vision. The curve plotted from the vision of deuteronopes is known to be practically normal, and so seems to be that of tritanopes ([10]).

Colour Characteristics of Monochromatic Radiations within the System R, G, V

$\bar{r}$	$\bar{g}$	$\bar{v}$	λ in $m\mu$	r	g	v
0.0000	0.0001	0.0066	380	0.0060	0.0115	0.9825
0.0001	0.0002	0.0201	390	0.0058	0.0116	0.9826
0.0004	0.0008	0.0625	400	0.0057	0.0118	0.9825
0.0012	0.0025	0.2057	410	0.0057	0.0122	0.9821
0.0040	0.0088	0.6459	420	0.0061	0.0134	0.9805
0.0116	0.0251	1.3856	430	0.0082	0.0176	0.9742
0.0230	0.0474	1.7402	440	0.0127	0.0262	0.9621
0.0380	0.0760	1.7727	450	0.0201	0.0403	0.9396
0.0600	0.1163	1.6693	460	0.0325	0.0630	0.9045
0.0910	0.1639	1.2880	470	0.0590	0.1062	0.8348
0.1390	0.2271	0.8128	480	0.1179	0.1926	0.6895
0.2080	0.3150	0.4651	490	0.2105	0.3188	0.4707
0.3230	0.4643	0.2720	500	0.3049	0.4383	0.2568
0.5030	0.6954	0.1582	510	9.3708	0.5126	0.1166
0.7100	0.9439	0.0783	520	0.4099	0.5449	0.0452
0.8620	1.0998	0.0421	530	0.4302	0.5488	0.0210
0.9540	1.1652	0.0204	540	0.4459	0.5446	0.0095
0.9950	1.1538	0.0088	550	0.4612	0.5347	0.0041
0.9950	1.0792	0.0039	560	0.4788	0.5193	0.0019
0.9520	0.9434	0.0021	570	0.5017	0.4972	0.0011
0.8700	0.7609	0.0015	580	0.5330	0.4661	0.0009
0.7570	0.5565	0.0012	590	0.5758	0.4233	0.0009
0 6310	0.3689	0.0008	600	0.6306	0.3686	0.0008
0.5030	0.2221	0.0004	610	0.6933	0.3061	0.0006
0.3810	0.1245	0.0002	620	0.7534	0.2462	0.0004
0.2650	0.0645	0.0001	630	0.8040	0.1957	0.0003
0.1750	0.0317	0.0000	640	0.8466	0.1534	0.0000
0.1070	0.0149	—	650	0.8776	0.1224	—
0.0610	0.0070	—	660	0.8972	0.1028	—
0.0320	0.0032	—	670	0.9090	0.0910	—
0.0170	0.0016	—	680	0.9151	0.0849	—
0.0082	0.0007	—	690	0.9206	0.0794	—
0.0041	0.0003	—	700	0.9222	0.0778	—
0.0021	0.0002	—	710	0.9219	0.0781	—
0.0011	0.0001	—	720	0.9219	0.0781	—
0.0005	0.0000	—	730	0.9219	0.0781	—
0.0003	0.0000	—	740	0.9219	0.0781	—
0.0001	0.0000	—	750	0.9219	0.0781	—
0.0001	0.0000	—	760	0.9219	0.0781	—
0.0000	0.0000	—	770	2.9219	0.0781	—

From these experimental data the following mnemonic rule may be established for the curve of vision. The curve of vision coincides in all cases with that curve of the sensitivity of operative receptors which corresponds to the largest wave-length. The luminosity coefficient of the corresponding primary colour should be put at unity, and the luminosity coefficients of the remaining colours, at zero.

The points of intersection of the curves in Fig. 1 should correspond to those wave-lengths which are «neutral» for the different types of dichromates. According to experimental data, these «neutral» points are situated in the following way (adopted from Judd [10]): for protanopes at 493 mμ, for deuteronopes at 497 mμ, and for tritanopes at 572 mμ.

When these numbers are compared with the position of the points of intersection of the curves plotted for $\bar{r}$, g and $\bar{v}$ in Fig. 1, one cannot help feeling strongly impressed by the accuracy of coincidence.

The trichromatic coefficients of r, g and v which are given in the table adjoined make it possible to plot a colour diagram r, g, similar to the commonly used x, y diagram (Fig. 2).

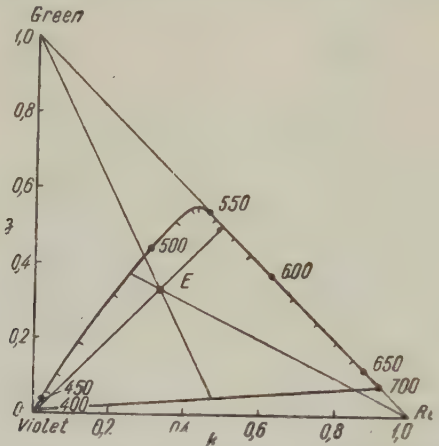


Fig. 2. Colour triangle (rectangular) at whose apices are situated the primary colours Red, Green and Violet

At the apices of the triangle are plotted the primary colours, Red, Green and Violet. The chromaticities of the radiations, which are similar for dichromates and different for normal observers, are plotted along the straight line which pass through the apices of the triangles, while the wave-lengths of the points neutral for the dichromates are determined by the points of intersection of the spectral curve with the lines connecting the apices of the triangle with the point E.

The State Optical Institute.

Received
18.XI.1944.

REFERENCES

[1] D. B. Judd, Optic. Soc. Amer., **33,** № 6, 351 (1943). [2] A. König, Gesammelte Abhandl., No. 21, 214. [3] W. Abney, Researches in Colour Vision, London, 1913, [4] W. D. Wright, Trans. Optic. Soc., **33,** 141 (1928—1929). [5] J. Guild, Philos. Trans. (A), **230,** No. 685, 149 (1931). [6] Th. Young, Lectures on Natural Philos. (London), **2,** 345, 1805 (cited after Judd ([10])). [7] J. C. Maxwell, Trans. Roy. Soc. Edinburgh, **21,** 275 (1885) (cited after Judd ([10])). [8] H. Helmholtz, Handb. d. Physiol. Optik, 3 Aufl., II, 123, 1911. [9] F. H. G. Pitt, Med. Res. Council, Special Report, Series. No. 200, London, 1935. [10] D. B. Judd, J. Optic. Soc. Amer., **33,** No. 6, 294 (1943).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

CHIMIE

TRANSFORMATION CATALYTIQUE DE L'ALCOOL ALLYLIQUE EN ACROLÉINE PAR OXYDATION

Par P. V. ZIMAKOV et V. A. POKROVSKY

(Présenté par A. N. Nesmeyanov de l'Académie, le 6.XII.1944)

L'alcool allylique peut être oxydé aussi bien au point de la double liaison qu'à celui de la fonction alcool. En effectuant l'oxydation de l'alcool allylique dans une solution aqueuse de permanganate de potasse neutre Wagner a obtenu la glycérine avec rendement de 80 pour 100 (1)

$$CH_2=CH-CH_2OH \xrightarrow{+O+H_2O} CH_2OH-CHOH-CH_2OH$$

Prilejaef effectua aussi l'oxydation de cet alcool au point de la liaison double à l'aide de hydroperoxyde de benzoyl dans une solution d'ether (2). Il constata que dans ces conditions le glycide forme pratiquement l'unique produit de l'oxydation

$$CH_2=CH-CH_2OH \xrightarrow{+O} CH_2-CH-CH_2OH \quad (O)$$

Ainsi dans les dissolvants à températurcs basses l'alcool allylique s'oxyde facilement; cette réaction a surtout lieu au point de la liaison double. La tentative de transformer l'alcool allylique en acroléine par oxydation avec un bon rendement dans les conditions identiques ne réussissait point pendant une période de temps assez longue (3).

Pareille oxydation n'eut lieu qu'à des températures plus élevées et sur des catalyseurs. En faisant passer un mélange de vapeurs d'alcool et d'air au-dessus d'une spirale de platine chauffée à rouge Trillat réussit à obtenir l'acroléine, en même temps que d'autres produits d'oxydation, avec un rendement de 5 pour 100 (4).

Moureu et Mignonac (5) ont obtenu le meilleur rendement en oxydant cet alcohol au moyen d'air à 350° C en présence d'un catalyseur préparé en précipitant de l'argent en dispersion fine sur l'asbeste. Leur rendement atteignait 30 pour 100 de l'alcool transformé et 75 pour 100 de ce que prévoit la théorie.

Pendant les dernières dix années il a été constaté qu'avec l'argent activé, convenablement préparé, il est possible d'arriver à une oxydation d'éthylène au moyen d'air avec formation d'oxyde d'éthylène (6).

Nous nous sommes posé comme but d'effectuer l'oxydation de l'alcool allylique en présence d'un catalyseur d'argent, et autant que possible dans les mêmes conditions que celles où l'éthylène fut transformé en oxyde d'éthylène par oxydation.

Pendant nos essais le catalyseur d'argent activé se trouvait dans un tube de verre dont le diamètre était 20 mm, formant une couche de 100 et 300 mm. La température était déterminée à l'aide d'un couple thermoélectrique introduit au sein du catalyseur chauffé à rouge au moyen d'un poêle électrique en forme de tube. Nous nous sommes servis pour l'oxydation d'alcool allylique anhydre pure (la température d'ébullition étant 96.6°, $n\frac{20}{D}=1.4135$).

Le mélange était préparé en saturant l'air avec des vapeurs d'alcool allylique à une température définie. La présence d'acroléine dans les produits de la réaction était constatée au moyen d'hydroxylamine chlorohydrique, et dans certains cas, losque les produits de la réaction furent congélés à l'aide d'air liquide, on les distillait en dégageant les fractions d'acroléine pure et en définissant ses constantes.

Le tableau 1 donne les résultats de cette transformation en acroléine par oxydation sur un catalyseur d'argent activé. Le tableau 1 montre qu'avec une faible concentration de vapeurs d'alcool allylique il se transforme en acroléine d'une manière tout à fait élective, puisqu'on n'obtient pas d'autres produits de l'oxydation, exception faite de l'acroléine, qui se forme avec un rendement au-dessus de 75 centièmes théoriques; la faible concentration d'acide carbonique dans les gaz d'échappement en est la preuve.

Tableau 1

Oxydation de l'alcool allylique par l'air sur un catalyseur d'argent

Vitesse de passage d'air, 1/h	Quantité de l'alcool dans l'air, vol. %	Température de l'oxydation, °C	Rendement d'acroléine à l'égard de la théorie, %	Quantité de CO_2 dans les gaz d'échappement, vol. %
Longueur de la couche du catalyseur étant de 100 mm				
15	2.0	200—240	76.0	—
15	2.2	250	74.3	0.1
15	2.8	250	68.5	0.1
Longueur de la couche du catalyseur étant de 300 mm				
30	13	220	61	8.2
30	19	200	70	5.7

Si la concentration de l'alcool allylique dans l'air est considérable, le dégagement de l'acroléine est maintenu à une valeur assez haute (à 70 pour 100), mais une quantité notable d'alcool est brûlé en CO_2, malgré une température d'oxydation basse.

Notons qu'à l'oxydation de l'éthylène par l'air sur un catalyseur d'argent actif, la formation d'oxyde d'éthylène diminue aussi à mesure que la concentration d'éthylène dans son mélange avec l'air augmente. En même temps la quantité d'acide carbonique dans les gaz d'échappement devient de plus en plus grande. Le tableau 1 montre que la température d'oxydation élective de l'alcool allylique en acroléine sur un catalyseur d'argent est comprise entre 200—250° C. Elle correspond à la température de la combustion de l'éthylène en oxyde sur le même catalyseur.

Sur le tableau 2 on voit les résultats de l'oxydation de l'alcool allylique sur un catalyseur autre que l'argent.

Le tableau 2 démontre qu'avec des conditions bien choisies on peut réussir à obtenir pour un catalyseur de cuivre un rendement d'acroléine allant jusqu'à 35 pour cent du rendement théorique et même encore plus grand pour quelques variétés de catalyseurs de cuivre, quoique le pouvoir de ce catalyseur d'oxyder l'alcool allylique en CO_2 et H_2O dépasse celui du catalyseur d'argent.

Quant à la transformation de l'éthylène en oxyde d'éthylène, on n'a pas réussi jusqu'à présent à remplacer l'argent active par un autre catalyseur. Les autres

Tableau 2

L'oxydation de l'alcool allylique par l'air sur un catalyseur préparé avec l'oxyde de cuivre et du magnesium, leurs poids se comportant comme 1:1; la longueur de la couche du catalyseur étant de 300 mm

Vitesse du passage d'air, l/h	Quantité de l'alcool dans l'air, vol. %	Température de l'oxydation, °C	Rendement d'acroléine à l'égard de la théorie, %	Quantité de CO_2 dans les gaz d'échappement, vol. %
15	2.8	200	19	2.4
15	3.5	250	0.0	10
15	11.0	250	35	5

catalyseurs portent la combustion de l'éthylène jusqu'à l'état de CO_2 et de H_2O, tandis que la quantité d'oxyde d'éthylène formé est parfois très petite.

Il y a 50 années ([1]) que Wagner a énoncé l'hypothèse que l'alcool allylique, oxydé dans sa phase liquide en solution, l'est d'abord au point de la liaison double, et qu'il subit ensuite une hydration, accompagnée d'une formation de glycérine qui à son tour est sujette à des changements ultérieurs, qui varient suivant les conditions ([3]).

En nous basant sur les données expérimentales supplémentaires obtenues après Wagner (celles que nous avons mentionnées ci-dessus y comprises), nous pouvons supposer qu'une élévation de la température du catalyseur peut déterminer d'abord l'oxydation de l'alcool allylique en glycide au point de la liaison double. Les molécules du glycide (ou peut être leurs formes actives) sont très instables dans ces conditions à cause de leur structure électro-asymétrique, et se transforment en acroléine, en dégageant de l'eau grâce à leur structure, favorisant cette transformation

$$H_2C-C(O)-CH_2OH \rightarrow H_2C=CH-COH+H_2O$$

Cette conception du mécanisme de l'oxydation de l'alcool allylique en acroléine est confirmée par le fait que l'oxydation du propylène par l'air ne produit, malgré l'affirmation du brevet ([7]), que de l'acide carbonique et de l'eau, dans les conditions pareilles à celles de la combustion de l'éthylène en oxyde d'éthylène.

Selon notre avis, dans ce cas l'oxydation produirait d'abord un oxyde de propylène dont la molécule ne possède ni une symétrie électrique suffisante pour maintenir sa stabilité dans les conditions du procédé, ni une structure favorisant sa transformation en une forme stable, comme cela a lieu pendant l'oxydation de l'alcool allylique avec un rendement voisin du rendement théorique.

Manuscrit reçu
le 6.XII.1944.

LITTÉRATURE CITÉE

[1] G. Wagner, Ber., **21**, II, 3347; IV, 1231 (1888). [2] Н. Прилежаев, ЖРФХО, **43**, 610 (1911); Ber., **42**, 4813 (1909). [3] A. Cahours, A. Hofman, Ann., **102**, 291 (1857); B. Tollens, A. Rinne, Ann., **159**, 110 (1871); A. Kekulé, A. Rinne, Ber., **6**, 367 (1873). [4] A. Trillat, C. R. **133**, 822 (1901). [5] C. Moureu, G. Mignonac, C. R., **170**, 258 (1920). [6] Société Française de Catalyse Généralisée, brevet français 729952, No. 41810, 1933; K. Metzger, L. Andrussow, (J. G.), brevet américain 2178454, 1939; J. Stearn, B. Makower, P. Groggins, Ind. Eng. Chem., **32**, 1342 (1940). [7] Société Française de Catalyse Généralisée, brevet français 787896,1935.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

PHYSICAL CHEMISTRY

ON THE RELATION BETWEEN THE INDUCTION PERIOD AND THE CHEMISM OF A REACTION

By N. S. AKULOV, Member of the Academy of Sciences of the Belorussian SSR

In an earlier paper (1) the author showed the induction period to be a fundamental parameter characterizing the development of combustion reactions or, generally speaking, of reactions of the chain type, progressing through intermediate compounds*. There he evolved a method for computing the induction period τ as a function of the temperature T, the surface area S and the adsorption properties of the catalyst, for example, of the walls of the vessel, its volume V, the concentration C and the composition of the mixture γ_i. By this means was revealed the possibility of determining directly from the derived expression for τ (whichis confirmed by experiment) the position of all three limits of the self-ignition region. Thus, all the states of the substance are determined at which a gas spontaneously bursts into flame. Finally, it was shown that from the same expression for τ (T, C, γ_i, S, V) the position of the boundaries for all those states may be found, where a substance, for example, a gaseous mixture, may be ignited by an external source, acting as the initiator of the reaction. With this it was found possible also to establish the velocity of propagation of the cold flame as a function of the state of the gaseous mixture. The problem now confronting us is to find the relation between the equation for the induction period and the chemical mechanism of the reaction. This problem may be formulated as follows: given the concentrations of the reactants and the character of the elementary reactions from which the chain process is built up, established on the basis of chemical analysis of the resultants and intermediate products, to find the equation for the induction period as a function of the parameters T, C, S, V, $C\gamma_i$, where $C\gamma_i$ are the partial concentrations of the chemical components.

To solve this problem we will first of all derive an important general equation for the induction period. This new expression may be reduced to the one we have previously given; however, it does not require any additional assumptions if the «chemism» of the reaction is known. It is also applicable to an approximate analysis of the kinetics of the chain breakdown of uranium.

Let z_i be the number of molecules of the i-th intermediate product at the time t. Reacting with the reactants in the volume or adsorbed on the surface of the catalyst, these molecules again yield molecules of an intermediate product of the

* The discovery of chain (branched) reactions was made in 1903—1905, *i. e.* ten years before Bodenstein, by N. A. Šilov in the process of research to explain the induction period. Šilov proposed, for example, the following type of mechanism of the chain process: $B_1 + A_1 \rightarrow B_2$; $B_2 + A_2 \rightarrow 2B_1 +$ end product. Here A_1 and A_2 are the reactants, and B_1 and B_2 the intermediate products. Like authors after him, to describe the kinetics he employed a formula of the autocatalytic type. If upon the chain acceleration corresponding to Šilov's mechanism, energy acceleration is superimposed, as is usually the case, then autogenetic functions, as given by the author, must be employed to describe the kinetics. The magnitude of retardation defined by these functions was shown to be proportional to the induction period.

type j, and also molecules of the resultant. For the rate of accumulation of the intermediate product we will thus have an equation of the following type

$$\frac{dz_i}{dt} = \sum_j a_{ij} z_j \qquad (1)$$

where the coefficients a_{ij} depend upon the parameters T, C, ...

For the induction period we may regard the a_{ij} as constants. Then if no restricting conditions of the Bodenstein type ($dz_i/dt = 0$)* are imposed, we will have the following system of values of z_i, which is the solution of the linear system (1)

$$z = z_{0i} e^{kt} \quad (i = 1, 2, \ldots, n) \qquad (2)$$

For this k, as follows from the substitution of (2) into (1), should satisfy the following characteristic equation

$$A = \begin{vmatrix} a_{11}-k & a_{12} & a_{13} & a_{14} \ldots \ldots \\ a_{21} & a_{22}-k & a_{23} & a_{24} \ldots \ldots \\ a_{31} & a_{32} & a_{33}-k & a_{34} \ldots \ldots \\ a_{41} & a_{42} & a_{43} & a_{44}-k \ldots \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \end{vmatrix} = 0 \qquad (3)$$

This equation has with respect to k an order set by the number n of the different types of molecules of the intermediate product z_i. Equation (3) can be unfolded as follows

$$A = A_0 - \left(\sum_i A_i\right) k + \left(\sum_{ij} A_{ij}\right) k^2 \ldots = 0 \qquad (4)$$

where

$$A_0 = A_{k=0} \qquad (5)$$

and where A_i is the minor corresponding to the i-th diagonal term in A_0 (it is obtained upon canceling the lines and columns passing through a_{ii}).

Inasmuch as we are interested in states for which $\tau = k^{-1}$ is sufficiently great (in the limit $\tau = \infty$ and $k = 0$ for the boundaries of self-ignition), we must analyse (4) in the region of small k. It is easy to see that k is inversely proportional to τ. To establish this, we will define the induction period as the time required to attain a critical concentration $z_{\text{crit}} = z_{0i} e$. Then from (2) we get $\tau = k^{-1}$. Confining ourselves thus to the case of small k, we get the following basic relation

$$\tau = \frac{\sum_i A_i}{A_0} \qquad (6)$$

which, as we see, solves the given problem. Before going on to its applications let us reduce it to the illustrative expression given in foregoing papers

$$\tau = \frac{\Delta\tau}{\omega - 1} \qquad (7)$$

where $\Delta\tau$ is the time for the development of one link (on the average), and ω is the number of new molecules of the intermediate product obtained at the end of each link in place of that which entered into the reaction. For this we will group the positive and negative terms of the determinant A separately, representing the latter in the form of the difference $A = A_0' - A_0''$. Then, dividing the numerator and the denominator in (6) by A_0'', we get the expression in the form of (7), which makes it possible to judge of the magnitude

* The conditions of the type $dz_1/dt \neq 0$, $dz_2/dt = dz_3/dt = 0$ are incorrect.

of ω and $\Delta\tau$. For all practical purposes, however, it is sufficient to make use of expression (6).

To put an example we shall now examine its application to the reaction of oxidation of H_2S.

As end products in this reaction we have SO_2, H_2O and S_n, and as intermediate products, O, SO, and S. Reactions that yield SO_2 are usually assumed to be the elementary reactions $O_2+SO=SO_2+O$, which proceed by way of double collisions. In these reactions we are concerned with the simple dissociation of an atom of oxygen from a reactant oxygen molecule. But in the case of more complex processes where two atoms are exchanged between molecules, there is far less ground to suppose that they, too, proceed merely by way of double collision. That is why for the reaction of the formation of a molecule of water we assume the following mechanism. First, as the result of the collision of an atom of oxygen O with an H_2S molecule the active complex H_2SO is formed (highly unstable molecule of the type of the H_2O_2 molecule), which either again dissociates into H_2S and O, or colliding with any (catalysing) molecule may dissociate into H_2O and S. Thus, this reaction proceeds either by way of triple collisions, or with the participation of the walls of the vessel. So we have the following mechanism of the chain process

a) $O_2+SO \rightarrow SO_2+O, \quad O_2+S \rightarrow SO+O$

b) $\begin{cases} H_2S+O+M \rightarrow H_2O+S+M \\ \text{on the walls } H_2S+O \rightarrow H_2O+S \end{cases}$

where reactions of the b) type proceed on the walls of the vessel, or on the surface of the catalyst, on which H_2S may be adsorbed. A neighbouring molecule of the catalyst here plays the rôle of the third partner.

At not too small concentrations of H_2S it may be assumed that saturation adsorption* (according to Langmuir) occurs. According to the mechanism thus obtained, we will have the following system of equations:

$$\left.\begin{aligned} V\frac{d[O]}{dt} &= -(k_{11}V[H_2S]C+k'_{11}S)[O]+k_{12}V[O_2][SO]+k_{13}V[O_2][S] \\ V\frac{d[SO]}{dt} &= -k_{12}V[O_2][SO]+k_{13}V[O_2][S] \\ V\frac{d[S]}{dt} &= -(k_{11}V[H_2S]C+k''_{11}S)[O]-(k_{13}V[O_2]+k'_{13}S)[S] \end{aligned}\right\} \quad (8)$$

Contrary to the usual procedure (when employing the method of Bodenstein), we here take the whole numbers of molecules of the intermediate product that form every second in the reacting system, which permits us to conceive the rôle played by V and S. From (8) we may find A_0 and A_i.

Determining from (8) the determinant comprised of the coefficients before [O], [SO] and [S], we get

$$\begin{aligned} A = {} & k_{11}k_{12}k_{13}V^3C[O_2]^2[H_2S]+k^*_{11}k_{12}k_{13}V^2S[O_2]^2- \\ & -k_{11}k_{12}k'_{13}V^2SC[O_2][H_2O]-k'_{11}k_{12}k'_{13}VS[O_2] \end{aligned} \quad (9)$$

Determining the main minors and adding them up, we find

$$\begin{aligned} \sum A_i = {} & k_{12}k_{13}V^2[O_2]^2+(k_{12}k^*_{13}+k'''_{11}k_{13})VS[O_2]+ \\ & +k_{11}k_{12}V^2C[O_2][H_2S]+k_{11}k'_{12}VSC[H_2S]+k'_{11}k'_{13}S^2 \end{aligned} \quad (10)$$

where $k^*_{13}=k'_{13}+k'_{11}$ and $k^*_{11}=2k''_{11}-k'_{11}$.

Substitution of (9) and (10) into (6) gives $\tau([O_2][H_2S], V, S, T)$.

* Hence we have a reaction of order zero.

When $A_0 = 0$ we get the same equation for the boundaries of self-ignition, that was obtained with the aid of the method developed previously (for k_{ij} we must here take into account the law of Arrhenius)*.

It was then taken without proof that for large C the dependence of the branching factor upon the concentration obeys a square law. In the new method this additional assumption is unnecessary. All computations are carried out on the basis of an established (or accepted) chemical mechanism.

The derived equations, as we have already shown previously, are in quantitative agreement with experiment and are valid for all three limits of self-ignition (both on the C, T diagram and on the $C, C\gamma_i$ diagram). With this we also get their correct dependence upon $D = V/S$.

For the induction period $\tau(p)$ we obtain here the following expression

$$\tau = \frac{\tau_0 + \tau_1 p + \tau_2 p^2 + \tau_3 p^3}{p(p - p_1)(p - p_2)(p - p_3)} \tag{11}$$

where p_i $(i = 1, 2, 3)$ are the roots of the equation $A_0 = 0$, *i. e.*, the first, second and third limits.

Received
4.XII.1944.

REFERENCES

[1] N. Akulov, C. R. Acad. Sci. URSS, XXXIX, No. 5, 6, 8 (1943); XLIII, No. 7 (1944).

* For the sake of simplicity we assume that $E_{11} = E'_{11}$ and introduce the notation $E = E_{11} = E_{13}$.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

GEOCHEMISTRY

ON THE DISTRIBUTION OF LEAD IN SOILS

By S. I. SINIAKOVA

(Communicated by W. I. Vernadsky, Member of the Academy, 20. XI. 1944)

It has been pointed out by W. I. Vernadsky (1) that the greater part of lead atoms are in a dispersed state. However, all the information available on the distribution of lead in the Earth's crust is restricted chiefly to data on the content of lead in igneous rocks and in sea and river silts. Clarke and Steiger (3) have established an average content of $7.5 \cdot 10^{-6}$ g per 1 g of igneous rock. More recently Hevesy and Hobbie (3) have obtained a still more precise value of $1.6 \cdot 10^{-5}$ g of lead per 1 g of rock.

From the geochemical standpoint great interest belongs also to the data on the content of lead in soils. No systematic studies of the content of lead in soils have been made, however. The values obtained by Bertrandt and Okada (4) who studied the lead content of hydrochloric acid extracts from soils taken in the garden of the Pasteur Institute, are obviously overestimated. The values suggested by Bolotov (5) who investigated the lead content of hydrochloric acid extracts of soils from several towns in the USSR, are also too high. The higher lead content of the town soils can easily be accounted for by their being contaminated with industrial dust and dust formed in human dwellings. More reliable data are reported by Hibbard (6) for certain soils of California, in which the lead content in an acetic-acid extract varies from $0.5 \cdot 10^{-4}$ to $2 \cdot 10^{-3}$ per cent, according to the nature of the soil and depth of occurrence. A number of qualitative spectroscopic determinations of lead in soils are available, *e. g.* those by Milbourn (7), but they will not be considered here. The present investigation was carried out with the object to determine the lead content in the soils of the USSR.

Investigated were soils from various geographical and climatic zones, approximately along the 40th meridian in the European part of the USSR, beginning with the soils of marshy tundra (Khibiny) and ending with the krasnozem of Adjaria. Some soils were investigated also for their lead content along the vertical section, and thus an idea of the distribution of lead according to the depth of occurrence could be formed. Finally, a series of determinations of lead were made in nitric acid extracts of some soils. The data obtained make up the first information as to the lead content in the soils of the USSR.

A sample of soil weighing about 5 g was fused with soda, the melt was transferred into solution, and silicic acid was separated by the usual method. The enrichment of lead was made by extracting it with «dithizone» (diphenylthiocarbazone), in chloroform or carbon tetrachloride with which it forms an intercomplex salt (8).

The lead was extracted from a weakly ammoniacal solution, in which Fe and Al had previously been combined with citric acid into soluble complexes. Together with lead, Cd and Zn were also extracted under similar conditions. The dithizonates obtained were decomposed with hydrochloric acid (1 : 1), and upon

evaporation to dryness the residue was added several drops of perchloric acid and the solution was heated in order to remove traces of organic substances. The lead was determined by the polarographic method with ammonium acetate. As supporting electrolyte the sensitivity of the method is 1 γ of lead per cm^2. The measurements were made with the aid of Geirovsky's polarograph, the sensitivity of the galvanometer being 10^{-9} A. Lead from nitric acid extracts was determined by the same method. All the reagents were purified from lead by distillation or by treating them with dithizone solution in carbon tetrachloride or chloroform. The data obtained are given in the table.

Lead Content in Soils

Kind of soil	Place of sampling	Horizon and depth, in cm	Pb content in per cent to air-dry soil	
			total amount of lead, $\times 10^{-3}$	in nitric acid extract, $\times 10^{-4}$
Peat-gley	Marshy-tundra, Khibiny region	A_0 0— 15	none	—
Mountainous tundry	Region of Kirovsk	B 40— 80	»	—
Podzolized soil on bandy clay	Experim. forestry of Forest. Acad. Leningrad province	A 0— 5	0.38	—
Podzolized soil on boulder loam	Same	A 0— 5	1.70	—
Medium-podzolized loamy (light)	Forest plot of Timiriazev Agricult. Acad., Moscow province	A 0— 34 B 34—110	1.46 1.02	— —
Leached, grey, forest soil	Yasnaya Polyana, Tula province	A 0— 25 B 40— 80 C 100—105	4.33 1.30 —	3.2 2.2 1.4
Clayey ordinary chernozem	Station Talovaya, Voronesh province	A A_1 0— 5 B 80— 88 C 128—144	2.37 2.22 0.91 1.04	9.0 7.9 5.8 1.1
Loamy chernozem on a many-year deposit of a steppe elevated plateau	Same	A	0.26	—
Serozem of deserts	Terek-Kuma semi-desert, Bakress Soviet Farm	A 0— 50	0.63	—
Light-chestnut soil	Station Semichnaya, Rostov province	A	1.60	—
Chestnut soil	Same	A	—	0.3
Near-Azov czernozem	Station Salsk, Rostov province	A	0.37	0.4
Dark forest soil	Maikop, village Tulskaya	A	2.32	—
Krasnozem	Batumi Botanical Gardens	A 0— 10	1.00	—
	Average . .	—	1.23	3.5

The results obtained permit of the following conclusions. The lead content in the soils of the Soviet Union varies within one order. The highest lead content is found in forest soils (dark forest soil, grey forest soil) and clayey chernozem.

Podzolized soils, light-chestnut soils and krasnozem occupy an intermediate position. Poorer in lead are the near-Azov chernozem, loamy chernozem and serozem of deserts. Soils from tundra, which are richest in organic matter, contain no measurable amount of lead. The conclusion suggests itself that lead is not associated with the organic component of the soil. This conclusion seems to be supported by the author's experiments involving determination of lead in soils by the method of wet combustion with $H_2SO_4 + HNO_3 + HClO_4$ mixture, in which the organic portion of soil was entirely decomposed, and the lead content obtained was several times below that obtained when the same soil was treated by fusion. Hence, the greater part of the lead is associated with the sandy-clayey mass of the soil.

The investigation of the Pb content in the soil minerals separated out will shed additional light upon this problem. The lead content in nitric acid extracts is several times less than when the soil is treated by fusion, and in some soils makes up 1/10 of the total lead content of the soil. According to the author's analyses, the average lead content in soils is $1.23 \cdot 10^{-3}$ per cent. This result closely approaches the average lead content of igneous rocks as obtained by Hevesy and Hobbie ([2]). The lead content in soils along the vertical section, as shown by the author's data, decreases with depth; the ratio of the amount of lead between horizon A and horizon C attains 2 : 1 and 3 : 1. The analysis of polarograms shows that the cadmium content of soils is more than ten times less than that of lead; and the zinc content is considerably higher than the lead content.

Received
20.XI.1944.

REFERENCES

[1] В. И. Вернадский, Основные идеи геохимии, вып. II, 23, 1935. [2] F. W. Clarke and G. Steiger, J. of Washington Acad. of Sci., **4,** 58 (1914). [3] G. F. Hevesy and R. Hobbie, Z. analyt. Chem., **88,** 1 (1932); G. F. Hevesy, Forschr. d. Mineral., Kristall. und Petrogr., **16,** 2, 147 (1932). [4] G. Bertrandt et Y. Okada, C. R., **196,** 826 (1933). [5] М. П. Болотов, Гигиена и санитария, № 5, 49 (1938). [6] P. L. Hibbard, Soil Sci., **49,** 63 (1940). [7] M. Milbourn, J. Soc. Chem. Ind., **56,** 205 (1937). [8] H. Fischer u. G. Leopoldi, Z. analyt. Chem., **119,** 161 (1940).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

BIOCHEMISTRY

A PROCEDURE ENSURING THE PRESERVATION OF VITAMIN C IN LEAVES OF GLADIOLUS PREPARED FOR STORAGE

By N. A. MAXIMOV, Corresponding Member of the Academy,
J. V. RAKITIN and R. Kh. TUREZKAYA

Gladioluses are of great interest not only because of their ornamental value, but as a novel source of vitamin C. According to Giroud ([1]), the leaves of this plant contain up to 0.496 per cent of vitamin C (calculated for the fresh mass). Shmuck ([2]) studied 15 varieties of gladiolus and found some of them to contain up to 1.305 per cent of vitamin C (calculated for the fresh weight of leaves). Still more promising varieties were discovered in the course of our studies conducted during 1943 in Moscow ([3]). We have examined over 200 varieties of gladiolus and found among them a number of varieties containing from 1.5 to 1.7 per cent of vitamin C.

At the same time we also worked out all the fundamental rules pertaining to the cultivation and storage of gladioluses, as well as to the storage of raw material and preparation of vitamin infusions and concentrates.

In the present note we report the results of our studies of the factors which stabilize vitamin C in the fresh mass of gladioluses prepared for storage.

The wide experience accumulated in the practice of producing vitamin C from various plants points to the fact that the maximum output is obtained when the raw material is subjected to treatment immediately after harvesting; the longer it is kept, the greater is the loss in vitamin C. Practitioners have, therefore, long since arrived at a conclusion that the raw material should be worked immediately in order to prevent losses; or else the freshly harvested raw material should be brought into such condition as to make the losses in vitamin C as slight as possible.

When we undertook to find out the factors which stabilize vitamin C in gladioluses we thought that these practical observations would have a direct bearing upon the subject of our work. Our experiments have fully confirmed this anticipation.

The quantitative determination of vitamin C was made by us with the aid of indophenol titration under application of metaphosphoric acid ([4]).

Table 1 contains data illustrating the loss in vitamin C by fresh leaves of gladiolus, as dependent upon the duration of their storage at a temperature of 16° C.

From Table 1 it follows that the content of vitamin C is greatly reduced when fresh leaves are stored.

In order to avoid the undesirable loss in vitamin C we have decided to apply preliminary drying of the freshly harvested material. Common drying ovens worked by electricity were used for this purpose. As should be expected, the loss in

Table I

Variety	Vitamin C content in mg calculated pro 100 g of newly harvested leaves			
	initial content.	after 24 hrs.	after 48 hrs.	after 72 hrs.
Flaming Sword . . .	700	669	595	570
Apricot	500	469	431	350

vitamin C in the course of drying proved to differ according to temperature. Our experiments showed that the least loss was observed when the green mass was dried at 80—100° C. As shown in Table 2, the loss in vitamin did not exceed 30 per cent at this optimal temperature, while at temperatures departing to either side, the breakdown of the vitamin was found to be a more important one.

Table 2

Effect of Drying Temperature upon the Content of Vitamin C in Leaves of the Gladiolus Red Emperor (calculated for absolutely dry weight of leaves)

Drying temperature, °C	Vitamin C content in mg pro 100 g of the absolutely dry substance of the leaves		Loss in vitamin C in % to its content in initial leaves
	prior to drying	after drying	
20	5560	1070	80.70
40	5560	2540	54.32
60	5560	3220	42.09
80	5560	3950	28.98
100	5560	3890	30.02
120	5560	3020	45.67

It is known that the loss of vitamin C in the process of drying may be reduced in many cases by a preliminary treatment of the vegetable mass by sulphur dioxide (sulphitation). We undertook special investigations in order to check up the efficacy of this procedure as applied to gladioluses. Our first step in this direction was to determine the necessary quantity of sulphur to be burned, and the period during which the raw material was to be kept in the sulphur dioxide formed. It appeared that sulphitation proceeds successfully when 50 g of sulphur is taken pro 1 m^3 of the fumigating chamber, and when the green mass is left in the products of burning for 2 hours. At the beginning we used as fumigating chambers tightly covered glass jars; later on for the main experiments hermetic thermostats and drying ovens were used. The results of the sulphitation experiments are presented in Table 3.

It may be seen from Table 3 that the loss of vitamin C in the process of drying is only about 10 per cent when leaves are previously subjected to sulphitation, while in leaves which have not passed this treatment the loss in vitamin attains 30 per cent.

Sulphitation of the green mass of gladioluses is thus a measure of very high efficacy.

Table 3

Effect of Sulphitation upon Preservation of Vitamin C in Leaves of Gladioluses

Variety	Content of vitamin C in mg pro 100 g of absolutely dry matter of initial leaves	Leaves dried at 80°C without sulphitation		Leaves subjected to sulphitation and subsequently dried at 80°C	
		content of vitamin C in mg pro 100 g of absolutely dry matter of leaves	loss in vitamin C in % to its content in initial leaves	content of vitamin C in mg pro 100 g of absolutely dry matter of leaves	loss in vitamin C in % to its content in initial leaves
Red Emperor	5550	3885	30.00	4950	10.81
Frank Pendelton	5480	3880	29.20	4849	11.50
Faust	4940	3532	28.50	4426	10.40

The indices which characterize the quality of the raw material obtained after sulphitation and drying give an idea of the prospects opened for the vitamin industry by this method of storage. Without dwelling in more detail upon the subject, we find it sufficient to present here some figures illustrating the content of vitamin C in the raw mass of gladioluses harvested from every hectare of the plantation (Table 4).

Table 4

Content of Vitamin C in Green Mass of Gladioluses Harvested from one Hectare of Plantation (calculated for a variety containing 1.5 per cent of vitamin in leaves and 0.5 per cent in the flowering stems, fresh weight)

Planting material	Number of plants per hectare	Yield of green mass in centners			Content of vitamin C in kg		
		leaves	stems	total	newly harvested raw material	raw material dried at 80°C	dry material subjected to sulphitation and dried at 80°C
Large corms	269 thousands	53	27	80	93.0	65.1	83.7
Clones	1 million	54	6	60	84.0	58.8	75.6

It may be seen from Table 4 that the application of sulphitation and drying results in the preservation of an exceedingly high vitamin content in the raw material.

As may be seen from the calculation, the raw material that can be harvested from one hectare must contain from 75.6 to 83.7 kg of vitamin C, or about 1.5 millions of human doses (the daily dose is equal to 50 mg of the vitamin).

It is clear that a raw material of gladioluses containing such a high quantity of vitamin may serve for the production of a variety of preparation of vitamin C.

The K. A. Timiriazev Institute
of Plant Physiology.
Academy of Sciences of the USSR.

Received
14.III.1945.

REFERENCES

[1] Giroud, L'acide ascorbique dans la cellule et les tissus, Protoplasma—Monographien, **16,** (1938). [2] А. А. Шмук, Докл. ВАСХНИЛ, 11—12, 10 (1942). [3] N. A. Maximov, J. V. Rakitin and R. Kh. Turezkaya, C. R. Acad. Sci. URSS. XLVII, No. 2 (1945). [4] Glick, Z. f. physiol. Chem., **245,** 211 (1936).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

BIOCHEMISTRY

CONCENTRATION OF VITAMIN C IN CERTAIN PLANT SPECIES OF CENTRAL ASIA

By G. A. ZEPKOVA

(Communicated by A. A. Richter, Member of the Academy, 23. II. 1945)

Various wild and cultivated plants growing in Tashkent and the adjoining mountains were repeatedly analysed for their vitamin C content by the workers of the Department for Plant Physiology of this University in 1942. Wild rose was the first to be investigated on account of the suggestion made by Bukin (1), *viz.* that the pulp of the fruits of wild rose varieties growing in southern regions is much poorer in vitamin C than that of wild rose varieties of the northern and medium belt of this country.

Analyses of fruits of different alpine varieties of wild roses, collected by N. Karmysheva at the Aksu-Jabogly reserve at a height of 1800—3000 m above the sea level, have demonstrated in most of these species a vitamin C content ranging from 5180 to 17960 mg per 100 g of the dry weight of the pulp. The results of these analyses show that Bukin's statement cited above should not be adopted unreservedly.

Works by Čajlachjan (2) and Kirsanova (3) do likewise compromise it.

The high content of vitamin C seems to depend not only on the intrinsic properties of the plant, but on the height of its habitat above the sea level. Blagoveshchensky jun. (4) has reported for a number of garden crops grown at the Pamirs a content of vitamin C regularly increasing with height. Grebinsky (5) points out that the concentration of ascorbic acid in the leaves of plants growing under conditions of altitudinal climate is found to increase as the life conditions become less favourable, and the rate of growth lower.

In 1942 W. L. Iosselevich and G. A. Zepkova undertook at the Thalassa Ala-Tau (Aksu-Jabogly reserve) a comparative investigation of the content of ascorbic acid in representatives of certain families and of the course of its accumulation as dependent upon light conditions and altitude. At the same time T. J. Serghievskaya was determining the content of vitamin C in several plant species grown in Tashkent. In both cases the concentration of ascorbic acid was determined in freshly collected material. The analyses were carried out according to Thielmans' method, by titrating the hydrochloric acid extract with 0.001 *N* 2-6-dichlorophenolindophenol.

Table 1 illustrates the high vitamin content of wild alpine species of roses. The same figures bear out an increase in the accumulation of vitamin C, which takes place along with the ripening of the fruits.

The figures of Table 2 make it evident that the highest content of vitamin C is observed in representatives of the families *Rosaceae* and *Papilionaceae*. Among other families, grasses are found to be extremely low in ascorbic acid, while *Cam-*

Table 1

Concentration of Vitamin C in Fruits of Wild Rose Species Growing at High Altitudes*

Name	Vitamin C	Harvested on	Name	Vitamin C	Harvested on
Rosa Beggeriana Schrenk	1620	8.VII	*R. Fedtschenkoana* × *R. Webbiana* (Wall.)	6600	2.X
Do	7260	X	Do	6560	13.X
R. Fedtschenkoana Rgl.	1360	14.VII	*R. Alberti* (Rgl.) × *R. Fedtschenkoana* (Wall)	560	11.VII
Do	4690	23.IX	Do	340	12.VII
»	5650	1.X	»	9220	12.VIII
»	5180	2.X	*R. Fedtschenkoana* × *R. Xanthina*	5230	IX
»	1440	14.X	*R. Alberti* × *R. Sp.*	8870	1.X
»	1780	X	Do	8880	2.X
R. Fedtschenkoana × *R. Webbiana* (Wall.)	800	15.VII			
Do	4460	9.VII			
»	17960	23.IX			
»	5650	1.X			
»	8250	1.X			

* In Table 1, as well as in all subsequent tables, the content of vitamin C is given in mg per 100 g dry weight.

Table 2

Content of Vitamin C in the Leaves of Certain Plants

Name	Vitamin C	Name	Vitamin C
Axu-Jabogly Reserve			
(Detrmined by V. L. Iosselevich and G. A. Zepkova, in July—August 1942)			
Calamagrostis sp	171	*Hedysarum* sp	1375
Dactylis glomerata L	117	*Allium Drobovi* Vved	230
Eremopoa sp	114	*Allium polyphyllum* Kor. et Kir	250
Cychorium Inthybus L	176	*Malus pumila* Mill	3640
Cousinia sp	155	*Rosa Beggeriana* Schrenk	3860
Aster alatavicus Willd	220	*Sorbus persica* Hibt	900
Centaurea squarrosa Boiss	130	*Potentillia reptans* L	890
Origanum vulgare L	310	*Sanguisorba alpina* Rgl	2150
Stachys betonicaeflora Rupr	540	*Sanguisorba officinalis* L	590
Ziziphora clinopodioides Lam	450	*Althaea nudiflora* Lindl	950
Nepeta alatavica Lipsky	440	*Campanula glomerata* L	1290
Heracleum Olgae Rgl. et Schmalh	450	*Aquilegia Karelini* (Bacer) O. et B. Fedtsch	730
Aegopodium podagraria L	200	*Juniperus semiglobosa*	900
Ferula penninervis Rgl. et Schmalh	350		
Bupleurum linearifolium DC	190		
Medicago falcata L	806		
Lathyrus pratensis L	760		
Tashkent			
(Determined by T. J. Serghievskaya, in July—August 1942)			
Robinia pseudoacacia L	128.4	*Acer negundo* L	222.4
Gleditschia triacanthos L	131.0	*Acer pseudoplatanus* L	96.0
Albizzia julibrissin Durazz	382.4	*Tamarix* sp	148.6
Cercis seliquastrum L	113.5	*Juglans regia* L	6082.0
Amorpha fruticosa L	107.4	*Polygonum aviculare* L	376.0
Crataegus sp	75.8	*Heliotropium* sp	98.2
Pirus communis L	114.9	*Tribulus terrestris* L	83.7
Rosa canina L	77.17	*Atriplex* sp	282.0
Prunus armeniaca L	191.0	*Amaranthus retroflexus* L	230.2
Amygdalus sp	110.0		

panula glomerata, *Althaea nudiflora*, *Juniperus semiglobosa* are rich in it. The content of ascorbic acid in the leaves of plants growing in Tashkent are rather poor in ascorbic acid; *Juglans regia* L. which contains 6082 mg of ascorbic acid per 100 g of dry weight, is the only exception to this rule. Next, though much lower in ascorbic acid, follow *Althaea nudiflora* and *Juniperus semiglobosa*, with 950 and 900 mg per 100 g of dry weight, respectively.

As their habitats extend to higher altitudes, *Medicago tianschanica* and *Rosa Alberti* display a gradual increase in the content of vitamin C, the former in its leaves and the latter in the fruit (Table 3).

Table 3

Name	Vitamin C	Altitude in metres
Madicago tianschanica . .	805	1200
» » . .	1160	1800
» » . .	1570	2200
Rosa Alberti	1670	1800
» »	3600	2450
» »	3800	2750

Whilst drying fruits of *Rosa Beggeriana* and leaves of *Lathyrus pratensis*, it was found that the effect of sun radiation is to decompose ascorbic acid (Table 4).

Table 4

Name	Vitamin C	
	drying in the shade	drying in the sun
Rosa Beggeriana	1930	862
Lathyrus pratensis . . .	1660	1100

The content of vitamin C is also subject to fluctuation in the course of the day. Thus, in fruits of *Rosa* sp. it was found to be at a maximum at 12 o'clock in the day.

Table 5

Name	Vitamin C		
	6 a. m.	at noon	6 p. m.
Rosa sp. . .	7500	9100	7750

The concentration of ascorbic acid in the leaves of *Rosa* sp. at the period of fructification was found to be as low as 570 mg per 100 g of dry weight. The reduction in vitamin C content in leaves at the period of fructification has also been borne out by the results of analyses of leaves of fruitless and fruit-bearing individuals of *Malus pumila*.

Table 6

Name	Vitamin C	
Malus pumila, leaves . . .	Fruitless, 3970	Fruit-bearing. 1550

From all that has been said above the following conclusions are to be made:

1. As the rate of accumulation of vitamin C in wild roses rises along with the ripening of fruits, it is more advantageous to gather the fruit when fully ripe. It is preferable to collect the fruits about noon, for at this time they are especially high in vitamin C. Drying should be done in the shade.

2. Wild rose species growing at high altitudes are particularly valuable as a source of vitamin C.

3. Leaves of *Rosa* sp. and *Malus pumila* have been found to contain but insignificant amounts of vitamin C at the period of fruiting, which is probably associated with the migration of ascorbic acid from the leaves to the fruits.

The Central Asia University.

Received
23.II.1945.

REFERENCES

[1] В. Н. Букин, Витамины, 1941, стр. 201. [2] M. Ch. Čajlachjan, C. R. Acad. Sci. URSS, XL, No. 9 (1943). [3] В. А. Кирсанова, Биохимия, **9**, в. 1 (1944). [4] В. А. Благовещенский (мл.), Бюлл. экспер. биол. и мед., III, в. 2 (1937). [5] С. О. Гребинский, Биохимия, **6**, 3 (1941).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

GEOLOGY

THE KOVDORO-LAKE PLUTON OF ALKALINE AND ULTRABASIC ROCKS

By C. G. ZLATKIND

(Communicated by D. S. Beliankin, Member of the Academy, 27. XII; 1944)

The present note contains a brief survey of the main structural features of the Kovdoro pluton of alkaline and ultrabasic rocks, which the author was studying jointly with A. I. Shalimov in the summer and autumn of 1940. The Kovdoro-lake pluton is located in the south-western part of the Kola Peninsula, in the basin of the Yena River. Natural exposures occur in the marginal part of the pluton only, while throughout the rest of its area glacial deposits of variable thickness are extensively developed. For this reason until 1940 only the exocontact zone of the intrusion was known, and the geologists who visited the region described the massif as a semi-circle of alkaline syenites, cut by a series of ijolite dykes (1).

The investigations of 1940 were accompanied by large-scale stripping which showed the Kovdoro massif to represent an intrusion of the central type, having a concentric zonal structure. In the plan its shape approaches an oval one. The major axis stretched in north-western direction is 9 km long; the length of the axis perpendicular to this is 7.5 km.

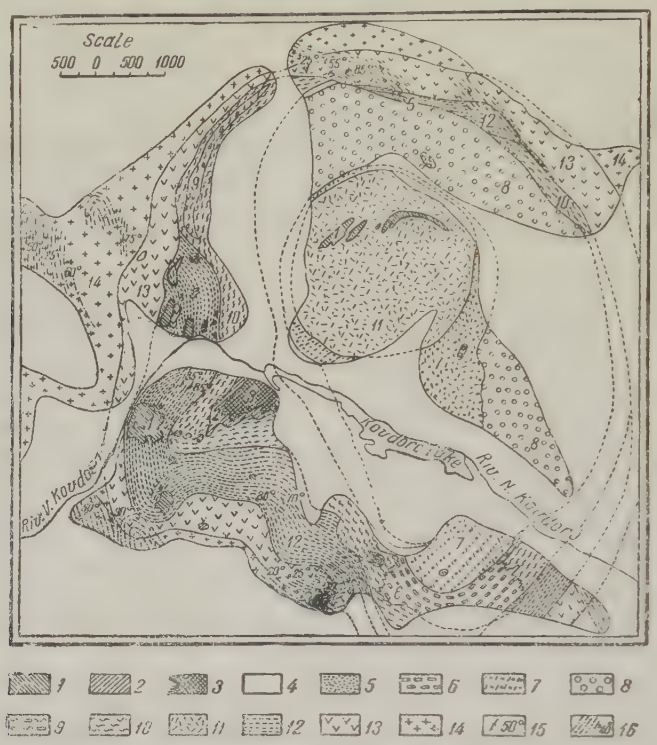
The enclosing rocks consist of strongly dislocated paragneisses of Svionian age, migmatized with microclinic granites. The central part of the pluton is composed of ultrabasic rocks represented by serpentinites, olivinites, and less frequently, peridotites and pyroxenites. The two latter varieties occur chiefly along the periphery of the area occupied by ultrabasites, near the contact with olivine turjaites. Olivine turjaites (kovdorites) represent a new variety of deep-seated melilitic rocks discovered by the author in the course of his exploration of the Kovdoro pluton in 1940. These rocks compose the first, inner ring around the ultrabasic core. The thickness of the ring of turjaites varies from 200 to 1500 m; in the south-eastern part of the pluton it is broken.

The next ring towards the periphery of the pluton, situated around the ring of olivine turjaites, is composed of ijolites, melteigites and jacupirangites. This ring is not continuous either, being broken at several points. Its maximum thickness attains 800 m.

The rocks of the ijolite-jacupirangite series are connected by gradual passages. The external ring engirdling the pluton from the periphery, is composed of contact-metasomatic rocks of the fenite series, among which predominate fenites proper (alkaline and rarely nepheline syenites), and fenitized gneisses.

Among the rocks of the fenite series gradual transitions from nepheline fenites to fenites and fenitized gneisses are everywhere observed, as well as transitions from the latter to gneisses, with traces of alkaline metasomatosis. The thickness of the zone of fenitization varies within the range of 100 to 1000 m; the greatest thickness is observed in the western and south-western parts of the pluton. The contacts between various zones of rocks composing the pluton are in most cases steep-dipping and vertical.

The olivine turjaites formed later then the ultrabasites and the rocks of the ijolite-jacuperangite do intensely affect the latter. The alterations are expressed in an enrichment of ultrabasites and rocks of the ijolite-jacupirangite series with mica of the phlogopite-biotite series, as a result of which the ring of olivine turjaites is fringed with zones of micaceous olivinites, ijolites and jacupirangites, forming passages to almost nomomineral micaceous rocks. The thickness of the zone of micafication varies from some scores of centimetres to a few hundred metres (less frequently). The transition of the micaceous olivinites, ijolites and jacupirangites to corresponding normal varieties is a very gradual one.



Geological map of the Kovdoro-lake pluton. Compiled by C. G. Zlatkind and A. I. Shalimov. Legend: *1*, carbonate rocks (carbonatites); *2*, metasomatically altered rocks of ore complex; *3*, olivine-apatite-magnetite and calcite-magnetite ores and rocks; *4*, Quaternary deposit; *5*, skarns (garnet-montichellitic, garnet-phlogopitic, *etc.*); *6*, micaceous rocks and micaceous ijolites. melteigites, jacupirangites; *7*, micaceous rocks and micaceous pyroxenites, peridotites and olivinites; *8*, olivine turjaites (kovdorites); *9*, porphyry-like ijolites, melteigites, jacupirangites; *10*, ijolites, melteigites, jacupirangites; *11*, serpentinites, olivinites, pyroxenites, peridotites; *12*, fenites; *13*, fenitized gneisses; *14*, gneisses with traces of alkaline metasomatism

Considerably enriched in mica is also the whole central part of the pluton (field of development of ultrabasites), where large areas composed of coarsely laminated mica are encountered.

Aside from the rocks listed above, within the Kovdoro-lake pluton are widespread calcite carbonatites, forming large lenses and bodies of irregular shape of various size. The carbonatites are most extensively developed in the southwestern part of the pluton, where they occur among fenites and fenitized gneisses, and partly among rocks of the ijolite series, and in the centre of the pluton among ultrabasites. At the contacts of carbonatites with the enclosing rocks phenomena of contact metasomatosis are observed. All the large bodies of carbonatites dip towards the centre of the pluton at an angle of 25—40° to the horizon.

Small stringers, lenses and pockets of carbonatites frequently occur nearly in all the alkaline and ultrabasic rocks of the pluton.

The complex of vein derivates of the intrusion comprises, in addition to vein carbonatites and carbonate-zeolite and mica-apatite rocks, also ijolites, melteigites, urtites, nepheline syenites, shonkinites, tinguaites, alkaline permatites.

The Kovdoro-lake pluton was formed during several phases of intrusive activity. The mechanism of magmatic activity during the individual phase consisted in the formation of more or less independent annular and conical intrusions which in their totality composed the pluton.

During the first phase occurred an intrusion of ultrabasic magma along a fracture, whose strike probably coincided with the strike of the enclosing gneisses predominant in the region, that is approached a north-western one. As a result of the intrusion of the first phase a body of ultrabasites was formed. Related to the hydrothermal processes at the close of the first phase probably was an intense serpentinization of ultrabasic rocks. The interval of time between the first and the second phase was characterized by an increase in the pressure of the magma chamber, as a result of which along the contact of gneisses and ultrabasites a system of annular fractures was formed, into which the magma intruded during the second phase.

The differentiation which proceeded in the chamber during the period between the first and the second phase was responsible for the fact that the magma, which intruded during the second phase, became saturated with alkalies, and upon crystallization produced rocks of the ijolite-jacupirangite series. Around the intrusion of ijolite magma a huge aureola of fenites and fenitized gneisses was formed. The vein facies related to the intrusion of the second phase and represented by vein rocks of the ijolite series, shonkinites and nepheline syenites, is confined to radial fissures in the body of the pluton, which for the intrusions of the central type are *Q* fissures.

The vein rocks enumerated break through ultrabasites, fenites and in some places through ijolites themselves, but have not been encountered in olivine turjaites, the intrusion of which was dissociated with the third phase of the intrusive activity of the bulk magma. The intrusion of the third phase penetrated through the contact between ultrabasites and rocks of the ijolite-jacupirangite series. It seems to have been preceded by subsidence phenomena in the central part of the pluton composed of ultrabasic rocks, as a result of which the annular fissure at the contact of alkaline rocks and ultrabasites was formed. Associated with the last manifestation of magmatic activity was the formation of the Yena ore complex.

The age of the Kovdoro-lake pluton, by analogy with other alkaline plutons of the Kola Peninsula, should be presumably considered as Hercynian. The closest analogues of the Kovdoro-lake pluton in the USSR are the massifs of ultrabasic and alkaline rocks of Africanda and Tyrii Cape at the Kola Peninsula ([1],[2],[5]). The Kovdoro-lake pluton has many features in common with the Swedish eruptive of Alnö.

Received
27.XII.1944.

REFERENCES

[1] В. А. Афанасьев, Сборн. Произв. силы Кольского полуострова, 1940. [2] Д. С. Белянкин, Труды Центр. петрографич. ин-та АН СССР, 2 (1932). [3] J. P. Iverson, C. R. Acad. Sci. URSS, XXX, № 4 (1941). [4] К. М. Кошиц, Известия Ленингр. геолого-гидро-геодез. треста, № 1 (1934). [5] П. Н. Чирвинский, М. С. Афанасьев, З. Г. Ушакова, Тр. Кольской базы АН СССР, в. 5 (1939).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

GEOLOGY

THE PRINCIPAL THESES OF THE GENETIC SYSTEMATICS OF INTRUSIVE BODIES

By A. A. POLKANOV, Member of the Academy

1. The genetic systematics of intrusive bodies can be based upon the following principal thesis: «Every intrusive body as a whole represents the state of equilibrium existing between the endogenic forces of the active magma, on the one hand, and the tectonics and kinematics of its enclosing frame, on the other. The internal structure of every intrusive body is controlled by the relation between the period of the crystallization of the magma and that of its endogenic kinematics, as well as by the synchronous kinematics of the frame». This principal thesis modifies and extends the statement previously advanced by H. Cloos (1).

The factors referred to in the first part of the newly advanced thesis control the principal geological features peculiar to intrusive bodies. The rôle of the activities displayed by subcrustal and intercrustal magma will now be discussed in detail.

2. The active forces of subcrustal magma take part in stimulating the kinematics of the Earth's crust, and, consequently, in giving rise to its tectonics, as well as in evoking magmatic activity. The active forces of intercrustal magma are made manifest: a) in the chemical effect produced on the formation of the frame, which is controlled by physical-chemical laws (migmatite- and migma-plutons); b) in the vertical motion of the magma columns, due to gravitation (migma- and diapir-plutons); c) in the hydrostatic pressure caused by the column of rising magma (central subvulcanoes, diapir dykes, sills, laccoliths-bysmaliths, partly lopoliths, interformational chonoliths, *etc.*); d) in the action caused by the disturbance of phase equilibrium in the gaseous-liquid magma (diatremes, necks). Hence four genetic types of intrusive bodies should be distinguished.

3. The two-storey, or many-storey cratigenic and orogenic constructions of the Earth's crust (I overcrustal formations, II, III, ..., socle) prove in themselves to be an almost impenetrable armour for the magma, but within them there are several directions favourable to the distribution and spreading of the magma (the anisotropic structures of rocks, the boundaries of layers and formations, stratigraphic and tectonic disconformities). The impenetrability of the cratogenic and orogenic constructions of the Earth's crust can be overcome only by its kinematics and by the active forces of the magma. The latter are modulated by the different tectonics and kinematics of the frame. Hence two principal groups of intrusions—those of the cratogenic regions and those of the orogenic regions—should be distinguished.

4. There are no less than 4 types of kinematics peculiar to the cratogenic regions of the Earth's crust, which are accompanied by magmatic activity: fractures a) of regional faults (Africa); b) of gigantic folds (the Rhine Elevation); c) of

the Moore—Cloos type (the Caledonian Foreland in Sweden and the Kola Peninsula); d) of tangential flexures (Oslo, the Kola Peninsula).

Accordingly, the following types of intrusions are found to occur in the I and II storey of cratogenic constructions: a) joint intrusive bodies which are synkinematic with the fracture of four genetic types, in which the frame is mostly passive (extension of the Earth's crust) and less frequently active (compression of the Earth's crust), and b) intrusions connected with the effect produced by the active magma (for the most part those of type 2b, c).

5. Three types of pro-orogenic, synorogenic and apo-orogenic intrusions are to be distinguished according to the different tectonics and kinematics of the Earth's crust in orogenic regions. In the pro-orogenic period the structure and kinematics in orogenic belts—both in those having and those devoid of geosynclinal preparation—are very much alike and also closely resemble those of cratogenic regions, differing from each other in the thickness of overcrustal formations and in the amplitude of vertical motions. Accordingly, the pro-orogenic intrusions of these regions are similar to those of cratogenic regions (dykes, sills, laccoliths, *etc.*).

In the synorogenic period, in accordance with the different tectonics and kinematics, the intrusive bodies of the orogenic regions are also different: a) either being devoid of geosynclinal preparation or b) having geosynclinical preparation. In the first case (a) the formations of socle are limited in their plastic deformations and disrupt in longitudinal fractures along which the kinematics of several hard blocks are found to occur. Contrary to this, overcrustal formations are subjected to folding plastic deformations, fractures and thrusts in which the blocks of socle also take part. In case of intrusive activity the magma penetrates into the lower storey along the fractures, and if its mass is small, the motion and distribution of magma is controlled by the kinematics of the hard blocks, and at a higher level by the kinematics of the plastic deformations in the overcrustal formations. Here the effects of magma activity are limited, but are found to increase as its mass grows in volume, reaching particular importance as the magma is spreading along the boundary of disconformity between the overcrustal formations and socle (plutons of West European variscid). In the second case (b), owing to the development of ultrametamorphism, universal plastic deformations are found to occur in both storeys, and the boundary between them is effaced. Upon being subjected to the universal kinematics of the frame, small masses of magma also take part in its motion, migrate and undergo considerable deformations which are the greater, the less yielding the plastic rocks of the frame are found to be. Only large masses of the magma are able to affect by their motion the nature and direction of the kinematics of the frame.

Thus, conformic and accordant intrusions of ophioliths proper of insular arcs, basic magma and granodiorites are found to originate, sometimes forming phacoliths, which are situated not only in geosynclines troughs, but into the overthrusts (Scandinavia). Ultrametamorphism results in granitization and in the origination of synkinematic magmatite-plutons, later on of longitudinal migmaplutons, and, finally, of diapir-plutons, owing to the chemical forces of the magma acting first and then being followed by the action of gravitation forces. However, under conditions of ultrametamorphism as well, the unequal plasticity of the rocks results in the origination of boudinage-structures and feather joints within which «interboudinage-plutons» and veins of feather joints are formed and filled with secretional magma. Here likewise «dead» boudinage-plutons are formed of pro-orogenic magmatic bodies.

6. Under apo-orogenic conditions the impenetrability of the Earth's crust of orogenic belts is disturbed by another type of kinematics, *i. e.* fractures which accompany the formation of gigantic folds, or the phenomena of epeirophorese. In the first case the kinematics is similar to that of cratogenic regions and their intrusions, thus being very much alike and differing only in the modulation of magma activity by the more complex tectonics inherited from the synorogenic period. In the second case disconformic transverse intrusive bodies are formed

in which the magma is crystallized under conditions of the frame being relatively passive, or, contrary to this, others in which the distribution of the magma is controlled by the kinematics of the frame and by the activity of the magma increasing in the upward direction. Hence in a number of cases these latter intrusions are similar to those of cratogenic regions.

7. The above data show that such factors as the activity of the magma and the tectonic and kinematics of the frame may serve as a basis for the classification of intrusive bodies. Only after the above suggested principal division it is possible further to distinguish and characterize the intrusions according to: a) their distribution into the different storeys and structures of cratogenic or orogenic regions; b) the relation between their boundaries and the structures of the frame; c) their shape; d) their relative size; e) the geological importance of the totality of certain types of intrusions among the totalities of other types of the same geological cycle.

8. The division of intrusions according to their inner nature and structure may be achieved by introducing the well known critera, namely those of «pluton» and «subvulcano», among which, in their turn, monophase, multiphase-multiple and composite intrusive bodies should be distinguished, and, finally, by applying to each intrusive phase the second part of the previously cited thesis (§ 1). This will permit to divide and characterize every type of intrusion, for it determines the evolution of the texture and structure facies of rocks, the types of telestructures of intrusive bodies, partly the types of the differentiation processes occurring *in situ* and even the types of endogenous and exogenous joint tectones. This final characteristic and subdivision of every intrusive phase may be formulated as follows.

9. According to the mode of their evolution intrusive bodies may be: I) primary procrystalline, or II) primary paracrystalline. The first type (I) of primary procrystalline intrusions in which the motion of the magma preceded crystallization (apoendokinetic crystallization), while the frame remained passive, shows a normal granitic textural facies of rocks. It can be divided into subtype A—of non-differentiated intrusions, having isotropic structures of rocks, and, consequently, a teleisotropic geological structure; and subtype B—of differentiated intrusions with anisotropic structures of rocks and a teleanisotropic geological structure. According to the arrangement of teleanisotropy we may distinguish conformic—non-autonomous intrusions (a vast number of sills, *etc.*), and disconformic—autonomous intrusions. The joint tectonics of type I is only connected with phenomena of contraction in cooling.

Type II of primary paracrystalline intrusions, in which crystallization was followed by a motion of the magma (synkinematic crystallization) is likewise divided into two subtypes.

Subtype A which is an endosynkinematic intrusion owing to the passivity of the frame, and has a granitic or sometimes a gneissose-granitic or gneissose tecture facies of rocks (at the border part of the intrusion). In this case the structures of rocks are always anisotropic, and therefore the intrusive bodies are teleanisotropic. They can be further divided into groups of non-autonomous (non viscous magma) and autonomous (viscous magma) intrusions which, in their turn, may be either differentiated or non-differentiated, and, finally, these can be further distinguished according to their internal structure (teledome-like, telespheroidal-shlieric). The joint tectonics of subtype A is endosynkinetic (partly the proper granitic tectonics of Cloos).

Subtype B is pansynkinetic, crystallization occurring simultaneously with the motions of the magma and those of the frame. The rocks have always a gneissose-granitic and gneissose structure facies of rock with anisotropic structures. The intrusive bodies may be teleanisotropic-autonomous (less frequently) and non-autonomous-conformic, and each of them may be differentiated (the types of differentiation) and non-differentiated. The joint tectonics is endo- or exosynkinetic.

10. Finally, if a solidified «dead» intrusive body is newly subjected to the

action of the kinematics of the frame, this results in its deformation and disjunction by fractures, faults, zones of tectonites and boudinage-structures, which may or may not be accompanied by pro-, para-, or apo-crystalline recrystallization, resulting in the formation of various metamorphic facies of rocks. These are pro-, para- and apocrystalline «dead» or «meta-intrusive» bodies.

Received
23.VII.1945.

REFERENCES

[1] H. C l o o s, Einführung in die Geologie, 1936, S. 75. See also my full paper with figures in the Proceedings of the 125th Anniversary Session of the Leningrad University, Section of Geology and Soil Science, 1945—1946.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

GEOLOGY

KAOLINS IN THE NORTH OF THE WEST-SIBERIAN LOWLANDS AND THEIR SIGNIFICANCE FOR THE KNOWLEDGE OF THE STRUCTURE OF THE REGION

By V. N. SAKS

(Communicated by V. A. Obruchev, Member of the Academy, 16. X. 1944)

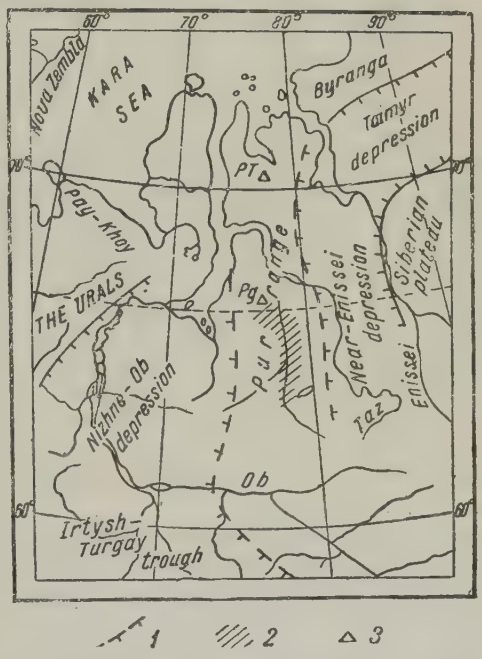
The first information on the occurrence of kaolins in the northern part of the West-Siberian lowlands was furnished by A. D. Fedoseyev, who published in 1938 the results of laboratory investigations of two specimens of clays, brought by A. V. Khabakov from the left-hand tributary of the Pur River—the Tab-Yakha ([6]). This information was reflected also on the geological map of the USSR, published in 1940, where the exposures of kaolins on the Tab-Yakha have been provisionally referred to the Tertiary period. Being among the staff of the expedition of the Mining-Geological Service of «Glavsevmorput»*, the author had the opportunity to examine in 1943 the exposures of kaolins on the Tab-Yakha River (Pangaptau-Nado plot) and on Sande-Yakha discharging into the Tab-Yakha from the left. New exposures of kaolin clays have been also discovered, forming lenses and streaks within white quartz sands, on the Pur River (Kamennaya Gora plot) and on the right-hand tributary of the Pur—the Khadyr-Yakha. In addition, some information has been gained from local inhabitants, concerning the presence of white clay exposures on the Aivaseda-Pur River, stream of the Kharam-Pur River. All this, along with pebbles of kaolin clays rather frequently encountered in Quaternary deposits of the basin of the Pur River, are evidence of a very wide, possibly universal development in the basin of the Pur of a serie of white quartz sands and kaolin clays under the Quaternary cover. Judging from the location of the exposures, the area of development of this series must be stretched in a meridional direction (see figure).

No sufficient data are available to form an idea as to the age of the series. No organic remains in the sands and clays have been discovered even under the microscope. A mineralogical analysis of several specimens showed a striking difference between the rocks of the series under consideration and the Quaternary deposits covering them. In the heavy fraction of Quaternary sediments the chief part is played by pyroxenes and amphiboles, products of decomposition of basic rocks (traps) of the Central Siberian plateau and Taimyr brought by glaciers. On the contrary, in kaolin clays and in the quartz sands interbedded with them the heavy fraction is represented by ore minerals (50—80 per cent), then by zircon (6—13 per cent), tourmaline and rutile. In this respect the series under consideration resembles the Palaeogene gaizes, found by the author on an isolated bare hill, the Parna-Sede, in the area between the left-hand tributaries of the Pur—the Tab-Yakha and Khadute rivers, as well as the Tertiary deposits in the lower course of the Ob, described by Vassiliev ([2]). The peculiarity of the series here considered consists in that it is enriched with quartz (73—97 per cent of the 0.1—

* Northern Sea Route.

0.01 mm fraction) and kaolinite (up to 82 per cent in clays), which is obviously related to the conditions of sedimentation. It seems that during the Tertiary period the conditions were particularly favourable for an accumulation of kaolinite, since in other regions, too (Ukraine, southern region of Western Siberia, Germany), secondary kaolinites are chiefly of Tertiary age. From Mesozoic, including the Upper Cretaceous deposits in the lower course of the Yenissei, as well as from Upper Jurassic rocks of the basin of the Ob (B. Jugan River) the series considered is rather markedly different: in its heavy fraction the epidote and amphibole grains characteristic of the Mesozoic are almost entirely lacking. Thus, in spite of the absence of analogues of the series of quartz sands and kaolin clays in the regions adjoining the basin of the Pur, the series should be in all probability assigned to the Tertiary, most probably to the Neogene. A Pliocene age is excluded, since in the sands exposed on the left-hand tributaries of the Tab-Yakha and containing Pliocene pollen, kaolin clay pebbles are already present.

The greatest interest in the series considered is presented by kaolin clays, occasionally passing into pure kaolins and forming amidst sands some lenses and irregular streaks from 10—30 cm to 1.5—2 m thick. These rocks are white-coloured, plastic and, as shown by analyses, have the following composition (recalculated to the absolutely dry weight:) Al_2O_3, 19.1—33.8 per cent; SiO_2, 53.6—61.1; TiO_2, 0.3—1.1; Fe_2O_3, 0.4—2.3; CaO, 0.4—0.8; MgO, 0.2—0.9; N_2O and K_2O, 0.1—1.0 per cent. Melting temperature, 1650—1760°. The most high-grade varieties of clays represent valuable raw material for fine ceramic ware and heavy duty refractories; they can be used also in the paper, rubber and paint industries. For the manufacture of refractory brick all the clays of the given series seem to be suitable. Of practical interest (for the glass industry) are also the quartz sands interbedded with clays, of which the silica content attains 93.7 per cent.



Tectonic scheme of the North of the West-Siberian lowlands. *1*, boundaries of tectonic depressions, established or presumable; *2*) area of development of kaolins in the basin of the Pur; *3*, exposures of ancient rocks within the lowlands (Pg, gaizes; Pt, traps)

The secondary origin of the kaolin clays in the basin of the Pur is beyond any doubt, but likewise obvious is the territorial proximity of the deposits of primary kaolins and kaolinized rocks, which have served as the source of supply during the formation of the kaolins discussed here. It should be noted that whichever of the existing theories of the origin of kaolin be accepted,—the theory of surface weathering, or the theory of hydrothermal and pneumatolitic processes of formation,—the parent rocks must have been fieldspathic, most probably igneous rocks. No large accumulations of kaolin that would not be related to the latter are known. It is likewise difficult to assume the appearance of kaolin deposits in the basin of the Pur as a result of a supply from the Urals, or from the hypothetical extension of the Urals to the Taimyr. The absence of kaolin rocks in the intervening regions, for instance, in the lower course of the Ob, is the best argument against such an assumption. The occurrence of the parent rocks in the basin of the Pur should be therefore assumed, since in not a single of the surrounding regions are kaolins so far known. At present these ancient rocks can be concealed from our view, but during the Tertiary they were eroded, at the expense of which

proceeded the formation of quartz sands and kaolin clays. There is no doubt that at present, too, the roof of the ancient rocks must lie at a shallow depth from the surface.

The fact of denudation of fieldspathic rocks in the basin of the Pur during the Tertiary is supported also by the enrichment of the light fraction of Palaeogene gaizes of the Parna-sedé bald mountain with fieldspars (94 per cent). The source of supply could not have been far away, since otherwise the fieldspars would have been subject at least to partial decomposition. Judging from the mineralogical composition of the heavy fraction of the Tertiary deposits of the Pur region (the presence of zircon, tourmaline, rutile), the fieldspars were formed in the first place at the expense of rocks of the type of granitoids. The quartz grains in the kaolin pebbles are, as a rule, fresh, transparent and slightly rounded, without any evidence of pressure. This fact suggests that the parent rocks were the comparatively young (Heroynian?) acid intrusions occurring not far from the Pur, and by no means the metamorphic formations of the pre-Cambrian. The occurrence of igneous rocks with stronger magnetic properties near the surface in the basin of the Pur is evidence of the existence here of positive magnetic anomalies. Finally, the findings in Permian conglomerates on the right-hand bank of the Yenissei (the region of Norilsk) of granite boulders up to 10—30 cm across indicate an erosion of granite intrusion which proceeded then somewhere near, most probably within the West-Siberian lowlands, in the basin of the Taz or Pur. The same is evidenced by the predominance in the sedimentary formations of the Tunguska series of products of decomposition of acid rocks, effusive ones included, which is recorded for the entire Tunguska basin. The denudation of mountain structures which began during the Permian proceeded throughout the whole Mesozoic. The Mesozoic deposits of the lower coarse of the Yenissei, of the Ust-Yenisseisk port in particular, were formed exclusively at the expense of an erosion of acid and metamorphic rocks, the most probable source of supply having been West Siberia.

Summing up all the aforesaid, the conclusion may be reached as to the existence in the basin of the Pur of a buried range, in the structure of which take part acid intrusions and which, hence, should be considered as a folded structure (acid intrusions are present only in folded areas). Such an inference fully confirms the prognosis made by Obruchev ([5]) that in the North of the Trans-Ob region the ancient rocks lie near the surface. Judging from the distribution of kaolin rocks, the buried range must be stretched in a meridional direction coinciding on the whole with the direction of the course of the Pur River. From the West and East it is confined by depressions, which fact is supported, in addition to the disappearance of kaolin deposits in the said direction, also by direct observations. West of the basin of the Pur, in the lower course of the Ob, Tertiary deposits are developed, attaining a thickness of 370 m, according to the data of Vassiliev ([3]). The older rocks, Palaeocene gaizes included, are subject to a considerable plunge, while on the Pur the gaizes are directly exposed at the surface.

It is true that gaize exposures occur also on the Ob, but these latter, according to Vassiliev ([3]), represent glacial fragments which may have been supplied from the foothills of the Urals. The Mesozoic strata in the Lower Ob depression lie probably at considerable depths, while on the southward extension of the Pur range the Mesozoic locally directly underlies the Quaternary cover. An evidence of this is presented by the fragments of the Upper Jurassic on the Big Yugan River, which can hardly have been brought from afar, and have most probably come from areas lying directly northward. The Lower Ob depression thus delineated, from all data available is a direct northward extension of the Irtysh-Turgay trough distinguished by Borissov ([1]). The existence of the second downwarping East of the Pur range is proved by drill-holes in the lower course of the Yenissei (Ust-Yenisseisk port), which revealed a plunge of the base of the Mesozoic down to a depth of 1000 m and more from the surface. The extension of this downwarping to the North-East is the Taimyr depression.

Both downwarpings distinguished, as well as the intervening elevation in the region of the Pur, according to all the data available, should be considered as a roughness of the Palaeozoic basement. The folded nature of the Pur range enables it to be included with the greatest probability in the zone of Heroynian folding, comprising the Urals and Taimyr. Most probably the folded Palaeozoic serves as a basement both for the near-Ob and the near-Yenissei depression (for the latter area this has been proved by the holes drilled in the Ust-Yenisseisk port). However, it is quite possible that here exist also old rigid areas, composed of slightly dislocated and slightly metamorphosed Palaeozoic sediments, like those of the Minusinsk and Kuznetsk depressions. The depressions formed during the post-Palaeozoic were subsequently continuing to warp down, being gradually filled as shown by the investigations in the more southerly regions of West Siberia ([1]), with loose Meso-Cenozoic deposits.

Considerable interest belongs to the problem of an extension of the Pur range to the South and North. In the South this buried range probably abuts on the Irtysh-Turgay trough, although the possibility is not excluded that it passes directly into the Ob uplift, separated out by Borissov ([1]). In the North the extension of the Pur range should be looked for in the western part of the Gydan Peninsula. There is some evidence pointing out to this. An exposure of traps on the Yuribei River has been established by Yermilov ([4]), although without great certainty. On the divide of the Yuribei and the Taz Bay, as I. P. Lughinetz has been informed by local inhalitants, black clay shales are exposed. Possibly, the Taimyr folded zone is an extension of the Pur range, while the Urals represent another, western, limb of a huge Hercynian orogen stretching from Kazakhstan to Taimyr and Nova Zembla.

Received
10.X.1944.

REFERENCES

[1] A. A. Borissov, Bull. Acad. Sci. URSS, sér. géol., № 3 (1944). [2] В. Г. Васильев, Вестн. Зап.-сиб. геол. упр., в. 3 (1939). [3] В. Г. Васильев, там же, в. 4 (1939). [4] И. Я. Ермилов, Тр. Полярн. ком., в. 20 (1935). [5] В. А. Обручев, Советск. Азия, 11—12 (1931). [6] А. Д. Федосеев, Огнеупоры, № 10 (1938).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

ECOLOGY

ON WINTER TRANSPIRATION IN DIFFERENT GEOGRAPHICAL RACES OF THE SAME PLANT SPECIES

By G. I. POPLAVSKA

(Communicated by V. N. Sukachev, Member of the Academy, 11. VI. 1945)

Data concerning the ecological significance of winter transpiration in plants are rather scanty. This problem is of great importance, however, in connexion with promoting of wood or shrub varieties to new districts. Gordyagin ([1],[2]) has shown that the main factor limiting the expansion of the oak eastwards is the high winter transpiration of this plant. Ivanov ([3]) has pointed to that the mode of winter transpiration should always be taken into account when deciding whether plant varieties of southern or medium latitudes can or cannot be grown in the North. He has also discovered a regular relation between the relative transpiration of various Eurasian woody plants and their geographical distribution. Indeed, the lower the relative transpiration of a woody or shrub variety, the farther they are able to extend to the North, or the higher to climb in mountainous regions. The same was found by Vassiliev([4]) to be true of different apple varieties. The existence of a correspondence between the transpiration in woody plants and their geographical distribution has also been emphasized by Ryazantzev ([5]) and Raskatov ([6]). Investigations by Weaver and Mogenson ([7]) on the comparative winter and autumn transpiration in conifers and broad-leaved trees are also to be mentioned here. Earlier papers devoted to this subject can be found in Burgerstein's review ([8–10]).

Thus, the literature concerning the problem of winter transpiration of woody plants is rather limited in general; but especially sparse are the informations as to the physiological attitude of representatives of the same species, and in particular of different geographical ecotypes, towards the hibernal losses in moisture.

Variations in the physiological behaviour of representatives of a single species at different geographical regions were described as far back as by Darwin ([11]). He remarked at this juncture that pines and rhododendrons grown from seeds collected by Hucker at different altitudes in the Himalaya mountains showed in England a different degree of cold-resistance. Turesson ([12]) showed experimentally that specimens of *Bellis perennis*, *Melandrium rubrum* and *Rumex acetosa* taken from different geographical districts but grown under identical conditions were found to possess a different degree of winter respiration intensity. Zvorykina and Kirpichnikov ([13]) also showed that larch and birch plants of different geographical origin displayed in Leningrad a different intensity of winter transpiration.

Winter transpiration was studied by the present author in *Salix viminalis* s. l., in 1935—1936. The experimental plants were taken from different geographical localities. The results of these experiments are described below.

Table 1

First Set of Experiments

Origin of experimental plants	No. of shoots	Weight of shoots in mg		Decrease in weight in mg from 10.XII to 16.XII (144 hrs.)	Decrease in weight in mg per 1 g in 1 hour	Average loss in weight in mg per 1 kg in 1 hour
		before 10.XII	after 16.XII			
Leningrad province . .	1	4010	3760	250	0.43	0.43±0.029
	2	6250	5900	350	0.38	
	3	5502	5120	382	0.48	
Kuibyshev province . .	1	5432	5180	252	0.32	0.32±0.004
	2	4960	4720	240	0.33	
	3	6290	6000	290	0.32	
Irkutsk	1	5680	5430	250	0.31	0.30±0.022
	2	4280	4120	160	0.26	
	3	4400	4190	210	0.33	

Table 2

Second Set of Experiments

Origin of experimental plants	No. of shoots	Weight of shoots in mg		Decrease in weight in mg from 16.XII to 24.XII (192 hrs.)	Decrease in weight in mg per 1 g in 1 hour	Average loss in weight in mg per 1 kg in 1 hour
		before 16.XII	after 24.XII			
Leningrad province, hairy shoots	1	3952	3700	252	0.33	0.34±0.022
	2	3750	3470	280	0.39	
	3	3230	3020	210	0.34	
	4	3800	3520	280	0.38	
	5	3550	3370	180	0.26	
Ibidem, naked shoots .	1	3252	3070	182	0.29	0.31±0.019
	2	3520	3270	250	0.37	
	3	2890	2710	180	0.32	
	4	3890	3670	220	0.29	
	5	3810	3600	210	0.29	
Kuibyshev province . .	1	3020	2900	120	0.12	0.21±0.013
	2	4150	3970	180	0.23	
	3	3720	3600	120	0.17	
	4	3510	3350	160	0.24	
	5	3560	3420	140	0.20	
Omsk	1	4340	4150	190	0.23	0.22±0.022
	2	4520	4322	102	0.12	
	3	4700	4500	200	0.22	
	4	4112	3970	142	0.18	
	5	4810	4580	230	0.25	
Irkutsk	1	4930	4750	180	0.19	0.23±0.007
	2	4752	4550	202	0.22	
	3	4000	3760	240	0.31	
	4	3620	3460	160	0 23	
	5	4600	4320	180	0.20	
Western Europe	1	4300	4000	300	0.36	0.37±0.004
	2	4140	3860	280	0.35	
	3	3880	3610	270	0.36	
	4	2900	2700	200	0.36	
	5	3850	3550	300	0.40	

The experimental plants were cultivated in a nursery near Leningrad. The origin of each plant was well-known, for they represented a part of the breeding material studied by V. N. Sukachev, Member of the Academy.

It should be pointed out that this willow has been divided by Nazarov ([14]) into several geographically isolated and very closely related species, viz. *Salix viminalis* s. str. (Western Europe), *S. rossica* (European part of the USSR, Eastern and Western Siberia), *S. pseudolinearis* Nas. (Far East).

Severed shoots were used for the experiments. Transpiration was determined by the gravimetrical method. Only one-year-old shoots nearly equal in length and thickness were taken for the experiments. After cutting off, the surface of the cut was covered with a thin vaseline layer. The shoots were then immediately weighed and suspended along a stretched cord. After 1—2 days the experimental shoots were weighed again. The experiments were performed in a glazed unheated room. Weighings were carried out at the same hour of the day (from 11 to 1 o'clock) and in the same sequence. The loss of water was calculated in mgs within 1 hour per 1 g of total weight of the shoot.

The first set of the experiments was carried on from 10.XII to 16.XII.1933. For this series were taken specimens of *Salix rossica* from Leningrad district (village Bor, near the issue of the Shelon river), from Kuibyshev district (Buzuluk wood), and from the town of Irkutsk (Siberia). The data of this experimental set are given in Table 1.

The data of Table 1 show that plants originating from Irkutsk and from Kuibyshev district displayed the least decrease in water content, while those from Leningrad district were characterized by the highest rate of water evaporation. The lowest and highest temperature during the experiments was —10° and —0.6° C, respectively. Relative humidity was 91—98 per cent. It should be pointed out that the room temperature at which the experiments were carried out, did not materially differ from out-of-door temperature.

The second set of experiments lasted from 16.XII to 24.XII. Under experiment were again varieties from Leningrad and Kuibyshev provinces, from Omsk, Irkutsk and also from Western Europe. Five shoots were taken from each of the varieties mentioned. Among the material taken from Leningrad, there were 5 naked shoots and 5 hairy ones. The results obtained are illustrated by Table 2.

Table 3

Third Set of Experiments

Origin of experimental plants	No. of shoots	Weight of shoots in mg		Decrease in weight in mg from 5.II at 8.II (72 hrs.)	Decrease in weight in mg per 1 g in 1 hour	Average loss in weight in mg per 1 kg in 1 hour
		before 5.II	after 8.II			
Leningrad province, hairy shoots	1	3630	3520	110	0.42	0.47±0.037
	2	2730	2650	80	0.39	
	3	3860	3740	120	0.43	
	4	4020	3870	150	0.52	
	5	3720	3570	150	0.56	
Ibidem, naked shoots .	1	3632	3530	102	0.39	0.39±0.021
	2	3610	3490	120	0.46	
	3	4200	4090	110	0.36	
	4	4100	4000	100	0.34	
	5	3370	3270	100	0.41	
Amur province	1	1722	1680	42	0.34	0.30±0.022
	2	1230	1200	30	0.34	
	3	1400	1370	30	0.30	
	4	1490	1450	30	0.28	
	5	1680	1650	30	0.25	

The lowest and highest temperature during the experiments were —11.6° and —0.4°C, respectively. The relative humidity was 72—95 per cent.

In this set of experiments the amount of water evaporated by the Kuibyshev, Siberian, Omsk and Irkutsk varieties was less than that of the Leningrad variety. The highest rate of evaporation was shown by the specimens taken from Western Europe. In addition, the hairy shoots were found to be characterized by a somewhat higher rate of evaporation as compared to the naked ones.

The third set of experiments was carried out from 5.II to 8.II.1936. The room temperature varied from —17.7° to—2.9° C. The relative humidity was 90—93 per cent. The data obtained are given in Table 3.

It will be seen from Table 3 that the shoots from the Amur variety evaporated the smallest amount of water as compared to those of Leningrad varieties. Among the latter, the naked shoots evaporated less water than hairy shoots.

The conclusions to be drawn from the experiments here described are as follows:

1. Winter transpiration is found to vary in different geographical forms of *Salix viminalis* s. l. cultivated under identical conditions in Leningrad. Varieties taken from continental regions (Kuibyshev, Omsk, Irkutsk, Amur) are characterized by a higher rate of water evaporation as compared to those taken from more humid regions (Leningrad province, Western Europe).

2. The rate of water evaporation in the hairy variety of *Salix rossica* has inexpectedly been found to exceed that in the naked variety of the same species. This interesting observation stands in need for further investigation.

Leningrad State University.

Received
11.VI.1945.

REFERENCES

[1] А. Гордягин, К флоре Акмолинской области, изд. Тобольского губ. музея, 1916. [2] А. Гордягин, Тр. об-ва естеств. при Казанском гос. ун-те, 1, вып. 5 (1925). [3] Л. Иванов, Изв. Ленингр. лесн. ин-та, XXXII (1925). [4] П. Васильев, Научно-агрон. журн., № 2 (1930). [5] А. Рязанцев, Изв. Пермск. биол. н.-и. ин-та, IX, вып. 1—3 (1932). [6] Л. Раскатов, Сов. ботаника, № 3 (1939). [7] Weaver and Mogenson, Bot. Gaz., LXVIII (1919). [8] A. Burgerstein, Die Transpiration der Pflanzen, 1904. [9] A. Burgerstein, Die Transpiration der Pflanzen. Erg.-Bd., 1920. [10] A. Burgerstein, Die Transpiration der Pflanzen, Zweiter Erg.-Bd., 1925. [11] Ch. Darwin, The Origin of Species, 1856, p. 167. [12] G. Turesson, Hereditas, XI (1928). [13] Н. Зворыкина и М. Кирпичников, Тр. Ленингр. об-ва естеств., XLVI, № 2 (1937). [14] М. И. Назаров, Флора СССР, V, 1936.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

ECOLOGY

ECOLOGICAL RELICTS OF MANCHURIAN FLORA CONSIDERED IN CONNEXION WITH CERTAIN PALAEOGEOGRAPHICAL RESTORATION

By V. B. SOCHAVA

(Communicated by V. N. Sukachev, Member of the Academy, 1. X. 1944)

The ecological peculiarities of an organism consist in such characters as are no less, but rather more liable to variation than its morphological features. Thus, the tertiary poplar, birch and even palm tree must have essentially differed from the recent ones as to their ecological peculiarities. This circumstance should be taken into account each time that attempts are made to restore the palaeogeographical relations that had existed at some remote epoch. Besides, when approaching at a phylocoenological angle the study of the ecology of species and phytocoenoses may contribute to the solution of many a palaeogeographical problem. The present author made an attempt to apply the ecological analysis of the relicts of the Manchurian flora with the aim to retrace the course of the post-Tertiary history of the nemoral vegetation of the Far East.

The pre-Manchurian-Japanese vegetation of the early Quaternary was undoubtedly ecologically differentiated; owing to the fluctuations in the physical-geographical process, certain ecological types did not become successive, others have survived up to the recent time, though in a strongly modified form. For example, the tertiary Amur-Ussurian landscape was characterized by hydrophytic and hydro-mesophytic formations which did not survive under the physical-geographical condition of the Quaternary. But isolated relicts of these formations have survived in the phytocoenoses of the Manchurian fratria (*Osmunda cinnamomea* L., *Alnus japonica* S. *et* Z., *Fraxinus manchurica* Rupr., and others); they represent nothing else than partly degenerated derivatives of the ancient hydro-mesophytic type, where extinct forms, like *Taxodium*, for example, were prevalent. The cause of the breakdown of Tertiary hydrophilous formations should be sought for in the fact that it is the plains partly covered with stagnant water that had been most badly affected at the approach of glaciation. Under these conditions the ancient Manchurian coenoses were superceded by boreal coenoses, whose components intruded as far as to the littoral of the Pacific during the later development stages of the Quaternary landscape.

The recent nemoral formations of the Manchurian fratria have become ecologically specialized: these are coenoses of eumesophytic type, of a varying degree of thermophily. They have developed to replace the ecological, morphological and phytocoelogical formations peculiar to the ancient pre-Manchurian-Japanese mesophilic complex which escaped the catastrophic changes of that epoch. The original components of the recent Manchurian mesophilic coenoses, which existed in this flora since the Tertiary, did not enter into its composition si-

multaneously, and are therefore of different age. Some of them must have differentiated as early as during the Upper Cretaceous (3). The classification of Manchurian relicts according to their age does not fully exhaust the interest of a geobotanist and palaeogeographer, since the Manchurian floristic complex went through a lengthy period of common development. The ecological and phytocoenological features which individual representatives of this complex owe to these formations, among which they had arisen, or where they existed previous to their migration to the Manchurian flora, have become either effaced or transformed in the course of this developmental process. At this juncture the classification of the relict Manchurian flora according to the ecological principle assumes certain importance.

The author finds it advisable to suggest the following classification of the relicts of the Manchurian flora into types, which may conventionally be called after the arboreal species which are most peculiar to each of these types.

1. The type of *Carpinus cordata* Blume, the most thermophilic species, with a long growing period corresponding to high air humidity. Among these should be referred: *Acer pseudosiboldianum* Kom., *Kalopanax ricinifolia* Miq., *Actinidia arguta* Planch., and some others. In this country the type is at the present time distributed all over the Southern Ussuri province.

2. The type of *Pinus korajensis* S. et Z. comprises less thermophilic relicts which show no clearly pronounced trend towards high air humidity. This type embraces many representatives of the cedar-broad-leaved formation, in particular: *Tilia amurensis* Kom., *T. Taqueti* Nakai, *T. manshurica* Rupr. et Max., *Acer mono* Max., *A. barbinerve* Max., *A. manshuricum* Max., *Betula costata* Tr. and many others.

3. The type of *Picea jezoensis* Carr. requires, despite its comparatively high cold-resistance, a rather high degree of air humidity. Its components are spread at relatively high altitudes in mountainous regions, extending rather far to the North and North-West. To this type belong: *Abies nephrolepis* Max., *Acer ukurunduense* Tr. et Mey, *Evonymus macroptera* Rupr., and some others.

4. The type of *Quercus mongolica* Fish. is endowed with certain features which characterize it as a hemixerophyte; at the same time it proves rather tolerant to short vegetation periods and withstands long winter frosts. From among woody species, to this type belong: *Betula dahurica* Pall.; from among shrubby plants, *Corylus heterophylla* Fisch. and *Lespedeza bicolor* Turcz. These species coexist with a variety of relict herbaceous plants.

5. The type of *Alnus japonica* S. and Z. combines both thermophilic plants requiring high air humidity and such as are adapted to moist soils, occasionally to soils gradually transforming into marshy ones. Aside from *Alnus japonica*, among these should be classed *Fraxinus manshurica* Rupr.; from among herbaceous plants, *Osmunda cinnamomea* L. and certain grasses.

6. The type of *Armeniaca manshurica* Köhne is a complex of both xeromesophytic and relatively thermophilic forms; it is mainly made up of herbaceous plants, largely of species endemic of the Maritime province. From woody plants it comprises, aside from *Prunus armeniaca*, also *Pinus funebris* Kom. and *Fraxinus rhynchophylla* Hance.

At the present time we are not in position to suggest a more detailed ecological classification of these relicts. Their future, more detailed ecological and biological subdivision is highly promising on account of possible historical floristic generalizations. As an example, let us point out a group of plants whose ecology and biology are of a relict type, one of the representatives of which is *Betula Schmidtii* Rgl. Being sufficiently luciphilic, it nevertheless proves to develop a slow growth. When growing in arid rocky regions, it requires high air humidity. Ecological and biological features of this kind could not possibly have been developed unless under highly peculiar conditions of the medium, quite different from the recent ones.

Many of the relicts of the Manchurian flora did not suffer any material morphological changes in the beginning of the Quaternary, which is evidenced by the

distribution of identical forms both over the Japan archipelago and the Maritime province of this country. Unlike these, other relict species have already had time to differentiate, as a result of which they are represented in Japan and on the continent by geographical substitutes. The ecology of relicts underwent more important changes within the post-Tertiary. The ecological types listed above seem to be neoformations that came into existence largely during the second half of the Quaternary. It may be assumed that quite different ecological types had been prevalent at the close of the Quaternary, as, for example, the *Zelkova*. This type, which is now extinct in the Maritime province, was adapted to a long period of vegetation, a gentler winter and a different precipitation regime. It was associated with laterization processes now revealed in fossile soils ([1],[5]).

The type of *Zelkova* implies physical-geographical conditions precluding the existence of most of the recent ecological types enumerated above. Conditions favourable for a wide development of representatives of the cold-resistant group (belonging to the type of *Picea jezoensis*) might scarcely has existed before the second half of the Quaternary. And this seems still less probable, if we take into account that the climate that prevailed in the northern and north-western part of the near-Amur region was more moderate than the modern one, which is partly corroborated by direct palaeobotanical evidence. We have, therefore, no reason to suppose that vegetation of the type of *Quercus mongolica* might have existed during the early Quaternary.

The differentiation of the ecological types characterized above may be imagined to have proceeded in the following way. At early stages (in the beginning of the Quaternary) had been differentiated the ecological type of *Carpinus cordata* which supplanted the type of *Zelkova*. Its components are peculiar to both Japan and the continent, belonging to the category of relicts which had escaped essential morphological variations during the Quaternary. The period of distribution of hornbeam and *Zelkova* in the near-Amur region and the littoral of the Pacific was synchronous to the first glaciation period at the Kamchatka ([4]). During this phase an intense circulation of atmosphere took place over the littoral of the Pacific; the vegetation period was therefore characterized by abundant precipitation, while the areas invaded by powerful currents of air driven from tropical seas had a relatively long and hot summer.

During the subsequent phase the circulation of atmosphere became less intense and the period of vegetation less humid; certain habitats even became arid. There was no rise in temperature as compared with the preceding phase, probably on account of the migration of the pole and the recession of the territory of the littoral of the Pacific from the tropics. During this phase the vegetation showed a trend towards the development of hemixerophytes; the type of *Armeniaca manshurica*, comprising numerous herbaceous xerophytes, became stable, and the ecological type of *Quercus mongolica* came into existence. This phase which approximately corresponds to the interglacial period at the Kamchatka, was of very long duration in the region of the littoral of the Pacific; the physical-geographical process seems to have suffered more than one throb within this period. The phase may appropriately be called the time of oak, since the formation of oak-groves is the most important botanical-geographical event that took place during this time.

The third phase was accompanied by a temperature decrease which, according to Grigoriev ([2]), was associated with an outbreak in the work of the Pacific centre of atmospheric action. This was a period of low temperatures and increased humidity, synchronous with the European Riss-Würm glacial stage. It was marked by the selection of cold-resistant forms and by a progressive development of the ecological type of *Picea jezoensis*. The time of *Picea jezoensis* coincided with the period of extinction of many an ancient thermophilic form, and with a total decay of the nemoral vegetation of the Pacific littoral.

The subsequent transformation of the physical-geographical process was again accompanied by an improvement in the climate: the temperature of the vegetation period increased, while the moisture content of the air went down occasionally. This phase, however, was remarkable for its instability, and the short-

lived periods of high temperature and a certain degree of xerophily alternated with periods during which the temperature was lower and air humidity higher. To these should be referred the recent period which may well be termed the time of *Pinus korajensis*. This name is justiied by the fact that the developing Ayan fir and the oak-groves gradually become independent of the nemoral vegetation. The ecological type of *Carpinus cordata* gradually becomes extinct, whereas the mixed Manchurian wood, which is characterized by *Pinus korajensis* as an ecological type, is now playing the rôle of the main preserver of the floristic and structural features of the pre-Manchurian-Japanese formation ([6]).

The development of the nemoral vegetation proper was accompanied by the intrusion into our territory of new phylocoenogenetic groups. The phase of the *Zelkova* and the hornbeam was marked by the intrusion of an element of the ancient Beringian tayga, partly under the cover of mixed woods, but principally to the open habitats of the upper mountainous belt. During the phase of the oak could possibly occur the invasion of certain elements of the Central-Asiatic xerophytic centre. The phase of the fir was accompanied by the formation of mountainous tundra phytocoenoses of the «goltzes», and of boreal marshy and meadowy vegetation in the plains. The recent phase of the Korean cedar is characterized by an expansion of Angarian boreal vegetation, among which the leading place is held by the Dahurian larch.

Geobotanical Department.
The W. L. Komarov Botanical Institute
Academy of Sciences of the USSR.

Received
1.X.1944.

REFERENCES

[1] К. Д. Глинка, Почвоведение (1911). [2] А. А. Григорьев, Проблемы физической географии, XI (1942). [3] А. Н. Криштофович, Геологический обзор стран Дальнего Востока, Л., 1932. [4] С. Л. Кушев и Ю. А. Ливеровский, Тр. ин-та географии АН СССР, XXXII (1940). [5] Н. И. Прохоров, Материалы к реконструкции хозяйства Приханкайской низменности, Хабаровск, 1927. [6] В. Б. Сочава, Сов. ботаника, № 1 (1944).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

EXPERIMENTAL MORPHOLOGY

REGENERATION OF MUSCLES IN *MAMMALIA*

By L. ZHINKIN

(Communicated by A. A. Zavarzin, Member of the Academy, 9. XII. 1944)

In spite of the great attention that has long since been paid to the problem of muscle regeneration, the results available are still the object of controversy. In *Mammalia* a connective-tissue scar is formed at the place of the wounded muscle, which is disorderly intergrown by separate muscle fibres. The impression is that muscular fibres are not capable of regeneration. On the other hand, after typhoid fever and in some other cases of gradual degeneration of contractile substance there is complete regeneration of the muscle (1).

The mode of regeneration of muscular tissue in *Mammalia* is also a matter of dispute. Two ways of regeneration of muscular fibres have as yet been described. The one is by way of myoblast formation, the other, by budding. Both modes of regeneration of muscle tissue were observed by certain authors in the same animal. Alongside of the formation of buds, many authors have also described the formation of myoblasts in regenerating muscles. In tissue cultures of embryonic muscle Chlopin (2) observed the formation of myoblasts, while in new-borns secondary differentiation was found to proceed by way of bud formation. The question arises as to whether the two modes of regeneration of muscular tissue here described are different in principle. On the other hand, of no less importance is the question as to the differences in the modes of regeneration of the muscle tissue in higher and lower vertebrates. It is known that in high vertebrates (fish, *Urodela*) muscle tissue is regenerating perfectly, while in lower vertebrates a connective-tissue scar is formed at the place of the injury.

When studying muscle grafts in rabbits, I made some observations on normal regeneration of striped musculature. The material was fixed 5 to 30 days after operation. But as the reactive changes in the muscles after grafting develop gradually, it was found possible to trace the whole process of regeneration, and especially the first stages of the changes in the muscle fibres. After the wound has been inflicted, the injured muscle fibre starts degenerating; decay may proceed either by way of granular, or vacuolated and cerous degeneration of the contractile substance.

The process of degeneration goes on under participation of phagocytes, leading to the formation of the characteristic «Muskelzellenschlauche» of Woldeier.

Simultaneously with degeneration, somewhat apart from the wound, alterations are seen to occur in the muscle nuclei of the injured fibre. The nuclei become rounded in shape and increase in zise. The chromatin is condensed into large nucleoli. After this the nuclei begin to divide amitotically, thus forming the characteristic «paths» of muscular nuclei. The contractile substance surrounding the

nuclei loses its structure and becomes more or less basophilous. The process results in the formation of a typical muscle bud at the end of the injured fibre. The muscle bud is growing inside the sarcolemic tube. Separate myoblasts may become detached from the end of the bud. These, however, do not take part in the regeneration of the muscular fibre. No distinct mitoses could be observed in the myoblasts. Later on the muscular bud formed grows out of the limits of the sarcolemic tube. From that time on the buds of the separate muscle fibres begin to grow in different directions, often forming a network consisting of separate new-formed muscular fibres (see figure). The new-forming muscular fibres are growing in every possible directions.

All these observations seem to show that the growth of the new-formed muscle fibres is an utterly uncontrolled one. Every bud, as soon as it passes the limits of the sarcolemic tube, begins to grow independently of the buds formed by the neighbouring muscle fibres, so that the structure of the muscle as a whole fails to regenerate. If degeneration of the contractile substance takes place, the myoblasts develop inside the sarcolemic tube, thus leading to normal regeneration of a whole muscle ([1]). Two circumstances invite attention in connexion with these observations. First, the correlations between the growth of the connective tissue and the regeneration of the muscular fibre. Secondly, the potencies of the muscular fibre. Zavarzin points out ([3],[4]) that the growth by way of buds may be regarded as a further development and improvement of the myoblastic mode of muscle regeneration. He thus fails to see any difference in principle between regeneration by means of buds, and myoblastic regeneration; if myoblasts are formed in lower vertebrates, both myoblasts and buds are formed in *Mammalia*.

Regeneration of muscular tissue in rabbit by way of bud formation. 20 days after operation

However, there exists a difference in the mode of the muscle regeneration in *Mammalia*, *Urodela* and fish, and this difference, in my opinion, consists in the following: According to Zavarzin's observations, muscle regeneration in fish is followed by the development of myoblasts which form anew a number of injured muscle fibres, thus leading to the regeneration of a whole muscle. The same mode of regeneration is known for invertebrates in which whole muscles are known to regenerate, and every muscle fibre is formed in connexion with its neighbour fibre, owing to which the muscle defect is filled up. In *Mammalia*, as well as in frogs ([5]) every muscle fibre is highly individualized and grows independently of its neighbour. This is the cause why the muscle as a whole is not capable of regeneration.

If intact sarcolemic tubes are present in an injured muscle, the muscular fibres are regenerating side-by-side in them, which leads to the regeneration of the muscle as a whole. This peculiarity of muscle regeneration in *Mammalia* is undoubtedly connected with the progressive differentiation of muscular tissue.

A second peculiarity, the existence of which we can but suggest, is the difference in the rate of regeneration of the muscular fibre and of the connective tissue in *Mammalia* and in *Urodela* and invertebrates. The normal course of regeneration is possible only in the case where the muscle defect is filled up with myoblasts or muscle buds before the connective-tissue elements will grow into the wounded muscle. However, the connective tissue of *Mammalia* responds to traumas so rapidly that the muscle buds do already grow into the connective tissue, which undoubtedly disturbs the normal course of regeneration of the muscle.

Thus, the limited regeneration of muscles in *Mammalia* depends, in the first place, upon limited potency of regeneration inherent in the muscular fibre itself, and, secondly, upon the rapid reaction of the connective tissue that prevents the normal regeneration of the muscular fibre.

Received
9.XII.1944.

REFERENCES

[1] R. Volcman, Ziegl. Beitr., 12 (1893). [2] Н. Хлопин, Арх. анат., гист. и эмбр., XXIII, № 1—2 (1940). [3] А. Заварзин, там же, XIX, № 3 (1938). [4] А. Заварзин, Очерки по эволюционной гистологии нервной системы, 1941. [5] З. Крюкова, Арх. анат., гист. и эмбр., XIX, № 3 (1938).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

ZOOLOGY

SEASONAL FLUCTUATIONS IN THE FREQUENCY OF BLACK HAMSTERS

By S. GERSHENSON

(Communicated by I. I. Schmalhausen, Member of the Academy, 3. XII. 1944)

A number of recent works have shown that the composition of wild populations of animals may undergo rather profound and regular variations from season to season, these variations being brought about by seasonal changes in the adaptive value of the various phenotypes present in the population. It seemed of considerable interest to find out whether such seasonal fluctuations exist in the dimorphic populations of hamster, consisting of commonly coloured and melanic individuals, which served as an object for our previous studies ([1],[2]), for this could shed light on the mechanism of regulating effect of natural selection upon the frequency of melanists within these populations. At our disposal were extensive data of the district fur-factories of «Sojuzpushnina» concerning the number of hamster-pelts purchased monthly in certain regions of the Ukrainian SSR during 1935—1939, and in all the Bashkirian ASSR during 1937—1939.

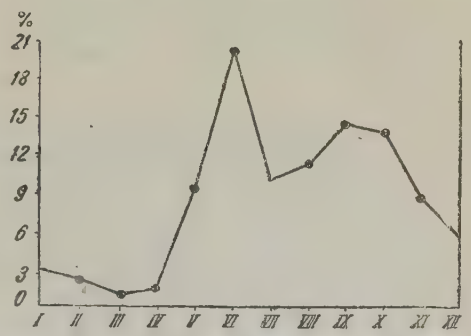


Fig. 1. Seasonal dynamics of the number of hamster-pelts purchased by the district factories of Poltava province (1935—1938)

In the present work we shall deal only with such regions where the total number of hamsters trapped monthly and the frequency of melanists among them are sufficiently high to avoid statistical errors leading to erroneous conclusions.

Before analysing the seasonal fluctuations of the frequency of black hamsters in these regions it was necessary to find out the lapse of time between the moment of trapping of hamsters and the selling of their pelts to the local factories. Two ways were used to solve this question: a questionnaire was distributed among a large number of trappers and fur-agents working over the territory investigated, and a study was undertaken of the seasonal dynamics of the number of hamster-pelts bought by the local fur-factories. It was found that the seasonal dynamics of the number of pelts purchased by the factories is in its main features identical in all the regions studied and remains practically constant from year to year. The type of these dynamics may be illustrated by the data concerning Poltava region (1935—1938) presented in Fig. 1.

On the basis of all the data collected, we divided the records for each year and region into the following four groups: (1) May—June, (2) July—August, (3) September—October, (4) November—April of the next year. The data for the first of these periods reflect fairly well the result of spring trapping; the few autumn

pelts which in rare cases could have been included into the May data, may safely be disregarded, their number being quite insignificant in comparison with the thousands of pelts obtained in spring. The data for the second and third periods are somewhat less precise, as they reflect not only the results of the corresponding months, but also include an admixture of pelts obtained earlier in the same year. Lastly, the data for the fourth period reflect nearly exclusively the results of the last autumn months of the trapping season.

In Figs. 2—5 curves are presented illustrating the seasonal fluctuations of the frequency of black hamsters in different regions of the Ukraine and in Bashkiria.

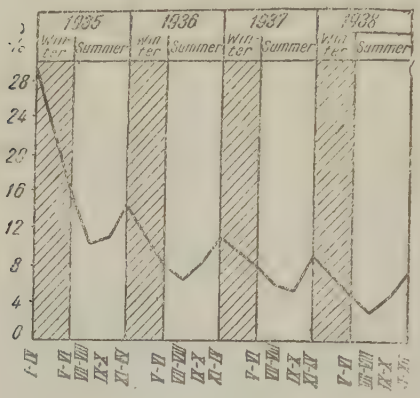


Fig. 2. Seasonal fluctuations in the frequency of black hamsters in Poltava province. Total number of pelts 147 461

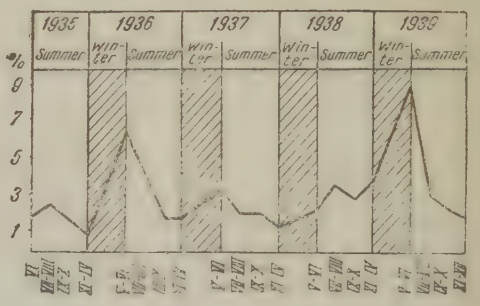


Fig. 3. Seasonal fluctuations in the frequency of black hamsters in Chernigov province. Total number of pelts 579 355

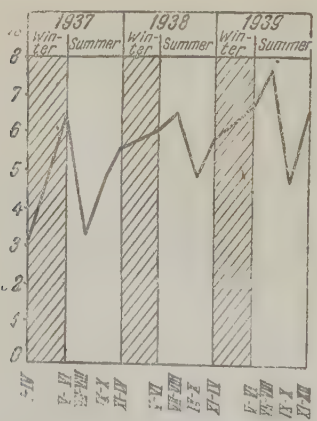


Fig. 4. Seasonal fluctuations in the frequency of black hamsters in Kamenetz-Podolsk province. Total number of pelts 216 157

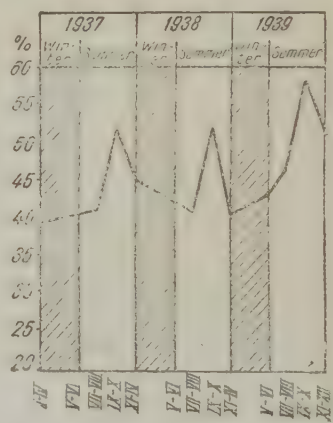


Fig. 5. Seasonal fluctuations in the frequency of black hamsters in the Bashkirian ASSR. Total number of pelts 1 055 495

As can be seen from these curves, the percentage of melanists in these regions undergoes very considerable seasonal fluctuations, the character of these fluctuations remaining relatively constant from year to year in each region, but greatly differing as to the region. All these seasonal fluctuations are statistically wholly significant.

In the Poltava province the percentage of black hamsters shows a sharp drop every year during the winter; this decrease continues during the spring and the first half of summer, after which a moderate increase takes place during the autumn months. These data clearly show that under the conditions existing in Poltava province the relative fitness of melanists differs according to the season.

Naturally enough, the mortality of melanists is much higher in winter than the mortality of common hamsters, since the decrease in the frequency of melanists during the winter-time can be explained only by differential elimination, no reproduction taking place during this season. If the vitality of usual hamsters during the winter be put at 1, then the vitality of melanists will be 0.44 for the winter of 1934—1935, 0.51 for the winter of 1935—1936, 0.69 for the winter of 1936—1937, and 0.56 for the winter of 1937—1938. It is this differential elimination of black hamsters in winter that is the cause of the considerable general decrease in the frequency of melanists in Poltava province, which took place during the period covered by our investigation. The decrease in the frequency of melanists in spring and summer and its increase in autumn may be caused either by differential mortality or by differential reproduction. Our material does not permit to decide between these alternatives, but some considerations make it probable that differential mortality is the chief factor.

Quite different is the picture observed in Chernigov and Kamenetz-Podolsk provinces. In both these provinces the frequency of melanists considerably increases during the winter, which can be ascribed only to their higher winter vitality as compared with that of common hamsters. If the vitality of common hamsters during the winter period be taken as unity, then the winter vitality of melanists will be expressed by the following figures:

	1935—36	1936—37	1937—38	1938—39
Chernigov province	7.05	2.05	1.95	2.50
Kamenetz-Podolsk province . . .	—	2.11	1.11	1.16

It is this better survival of melanists in winter that is responsible for the general increase in the frequency of melanists in Chernigov and Kamenetz-Podolsk provinces during the period investigated.

In Chernigov and Kamenetz-Podolsk provinces the summer fluctuations of the frequency of black hamsters are somewhat less regular. On the whole, the frequency of melanists somewhat decreases in summer, as a rule. Moreover, in Kamenetz-Podolsk province a short but pronounced decrease takes place towards the end of the summer, which is not observed in Chernigov province.

The seasonal fluctuations of the frequency of melanists in Bashkiria differ both from those observed in Poltava province and in Chernigov and Kamenetz-Podolsk provinces. In the winters of 1936—1937 and 1938—1939 the percentage of melanists somewhat increased, whereas in the winter of 1937—1938 it showed a slight decrease. During most of the summer months the frequency of black hamsters fluctuates more or less irregularly, but a sharp increase takes place at the end of every summer, followed by a sharp drop in autumn. On the whole, the seasonal fluctuations of the percentage of melanists in Bashkiria are relatively less expressed than in the provinces of the Ukraine studied by us.

Received
3.XII.1944.

REFERENCES

[1] S. Gershenson, C. R. Acad. Sci. URSS, XLVII, No. 8 (1945).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

ZOOLOGY

SOME NEW DATA ON THE STATUS OF THE GENUS *MYENNIS* R. D. (*DIPTERA, OTITIDAE*)

By A. A. STACKELBERG

(Communicated by E. N. Pavlovsky, Member of the Academy, 16. I. 1945)

The genus *Myennis* R. D. is confined to the Palaearctic region (Hennig, 1939); it includes 6 species, most of which are restricted to the zone of the broad-leaved forests. All these 6 species belong to the fauna of the USSR, and 5 of them have so far been found within the boundaries of the Soviet Union only. There are but very few data as to the distribution, life and habits of the species of the genus *Myennis*. Ecologically, the aforested areas constitute haunts suitable for most of the representatives of the genus (the development of their larvae, as far as we know, takes place under the bark of dead trees); the new species described (*M. monticola*, sp. n.) presents an exception in that respect: all the specimens obtained have been found above the forest zone in the Hissar Range (Tadjikistan) on stones along a mountain stream.

The present paper contains a key to the species, description of one new species, redescription of a species previously described insufficiently, and data on the distribution of the remaining 4 species.

Key of species

1 (2). Middle part of scutellum and basal part of abdomen broadly yellow. Wings with 4 oblique pale brownish bands; the first and the second bands at anterior margin broadly confluent. Legs yellow.

1. Myennis tricolor Hend.

2 (1). Scutellum and abdomen black, blackish brown or blackish grey throughout.

3 (4). Apical section of m near the middle with long appendix directed backwards. Apical and pre-apical cross-bands of wing in cell R_1 broadly confluent.

2. Myennis monticola, sp. n.

4 (3). Apical section of m without appendix. Apical and pre-apical cross-bands (spots) of wings not confluent.

5 (6). Section of m from rm to tp distinctly longer than tp. Apical spot of wing small, not reaching r_{2+3} and m. Dark bands of wing with numerous hyaline spots.

3. Myennis trypetoptera Hennig

6 (5). Section of m from rm to tp distinctly shorter than tp. Apical spot of wing large, extending from r_{2+3} to m. Dark bands of wing without hyaline spots.

7 (8). Pre-apical cross-band of wing developed all over the wing-breadth from apical part of cell R_1 to hind wing margin.

4. *Myennis sibirica* Portsch.

8 (7). Pre-apical dark spot of wing small, not reaching r_{4+5}.

9 (10). Cross-bands of wing oblique, yellowish or yellowish-brown with dark seams.

5. *Myennis octopunctata* Coqueb.

10 (9). Cross-bands of wing perpendicular and more or less unicolor.

6. *Myennis millepunctata* Hennig

1. *Myennis tricolor* Hend.

Hendel, 1909, Deutsche Entom. Zeitschr., Beiheft, p. 11; Hendel, 1909, in: Wytsman, Genera Insectorum, 96, p. 13, Taf. I, Fig. 15—17: Hennig, 1939, in: Lindner, Die Fliegen der paläarktischen Region, 128, p. 74—75.

Distribution. Turkomania.

2. *Myennis monticola*, sp. n.

Apical section of m with long appendix directed backwards. Apical and pre-apical cross-bands of wing broadly confluent at anterior margin.

Female. Head slightly broader than thorax. Frons about as broad as the eye. Lower part of occiput slightly swollen. Face, orbits, yowls and occiput, with exception of upper part of occiput, silvery white; upper part of occiput pale greyish. Frontal stripe reddish-yellow. Lower part of face at oral margin darkened. Antennae black; basal part ($^1/_5$) of arista thickened. Proboscis brown; palpi brown. Thorax black, with moderately dense greyish pruinosity; pleura paler. Mesonotum with two moderately broad, but short, dark, longitudinal stripes, developed only in the middle third of mesonotum, medially from the lines of dorsocentral bristles. Posterior corners of mesonotum broadly black, shining. Scutellum and postscutellum shining black. Abdomen shining black, with grey pruinose bands on the anterior half of the third, fourth and fifth tergits, first and second tergits with exception of basal part all grey pruinose. Ovipositor shining black; first segment of ovipositor about as long as three apical segments of abdomen. Legs black. Knees of anterior legs and bases of tarsi more or less brownish. Squamae and halteres whitish. Wings hyaline, with four brownish black cross-bands and similarly coloured base. Basal part of wing dark from anterior wing-margin to cu_1 and distally to about humeral and basal cross-veins. The first cross-band stretching from apical half of costal cell obliquely backwards and proximally through basal part of fork $r_{2+3} + r_{4+5}$, median part of anterior basal cell, basal part of discal cell and vein cu_2 to longitudinal ridge of anal lobe. The second cross-band, confluent with the first one at anterior wing-margin to r_{2+3}, occupies all Sc cell and stretches backwards and distally through both cross-veins (rm and tp) to hind wing-margin. Cross-veins very close to each other; section of m_1 from rm to tp about half as long as rm. Apical section of m near the middle with a long appendix directed backwards. The third cross-band confluent with the fourth (apical) cross-band in cell R_1, extending parallel to the second cross-band through veins r_{2+3}, r_{4+5}, m and appendix of m nearly to the hind margin. The fourth cross-band occupies the tip of wing up to vein m. Length 3.5 mm.

Distribution. Tadjikistan, central part of the Hissar Range, near Anzob Pass, 3000 m, 16.VI.1944 (3 ♀ ♀, Stackelberg leg.). Type in the Collection of Zoological Institute, Academy of Sciences, Leningrad.

3. *Myennis trypetoptera* Hennig

Hennig, 1939, in: Lindner, Die Fliegen der paläarktischen Region, 128, p. 75, Taf. V, Fig. 59.

Distribution. Vicinity Luga, Leningrad Province, NW Russia, June 1935, 1937, 1938, on trunks of old aspen-trees: together with this species were collected the following species: *Pseudowallacea hungarica* Kert., *Pachygaster orbi-*

talis Wahlb. (*Stratiomyiidae*), *Solva maculata* Mg. (*Erinnidae*), *Milichiella argyrogaster* Perr. (*Milichiidae*), different species of *Lonchaea* and also *Cerambycid*—beetles—*Saperda perforata* Pall. and *Xylotrechus rusticus* L.

4. *Myennis sibirica* Portsch.

Portschinsky, 1892, Horae Soc. Ent. Ross., 26, p. 213, Taf. I, Fig. 10; Hennig, 1939, in: Lindner, Die Fliegen der paläarktischen Region, 128, p. 74.

Female (Type). Head slightly broader than thorax. Frons distinctly broader than eye. Lower part of occiput swollen. Face yellowish, whitish pruinose, with a darkish transverse band at oral margin. Frons yellowish-brown, slightly darker behind. Yowls pale yellowish-brown. Occiput blackish-brown, whitish pruinose, in upper part moderately shining. Antennae yellowish-brown; arista in basal part ($^1/_5$) a little thickened. Proboscis blackish; palpi brownish. Thorax black. Mesonotum moderately densely brownish pruinose; front margin of mesonotum greyish pruinose. Scutellum shining black. Mesopleura brownish-grey pruinose; sternopleura shining black; pteropleura and hypopleura brownish, shining. Abdomen shining black, without pruinosity. Ovipositor shining black; the first segment of ovipositor nearly as long as three apical segments of abdomen taken together. Coxae and femora blackish brown. Tibiae yellowish-brown. Tarsi yellowish. Squamae and halteres yellowish-white. Wings hyaline with four blackish bands; two basal bands more or less oblique, two apical ones perpendicular. Basal part of wings from anterior margin to cu_1, and distally to the tip of sc brownish-black with two small clear spots in costal cell; the first blackish transverse band confluent in anterior part of wing with blackish base, behind cu_1 slightly narrowed and reaching posterior wing-margin at about middle of section from an to cu_1. The second blackish transverse band confluent with the first one between veins sc and r_{2+3}, occupies all sc cell, crossing both transverse veins (rm_2 and tp) and reaching hind wing-margin behind tip of cu_1. The third blackish transverse band from apical half of cell R_1, crossing middle of apical section of m_1, reaches hind wing-margin. The fourth blackish spot occupies apex of wing from tip of r_{2+3} to m. m section fr. m rm to tp about as long as rm and about half as long as tp.

Distribution. East Siberia (Baikal): 1 ♀ (type of Portshinsky) from Raddevka in the Collection of Zoological Institute, Academy of Sciences. Leningrad.

5. *Myennis octopunctata* Coqueb. (=*fasciata* F.)

Hennig, 1939, in: Lindner, Die Fliegen der paläarktischen Region, 128, pp. 73—74, Taf. V, Fig. 57, Textfig. 8.

Distribution. Middle and South Europe; South Russia: Kharkov, Sarepta; Tadjikistan; Ussuri Land.

6. *Myennis millepunctata* Hennig

Hennig, 1939, in: Lindner, Die Fliegen der paläarktischen Region, 128, p. 73, Taf. V, Fig. 58.

Distribution. Ussuri Land.

Zoological Institute.
Academy of Sciences of the USSR.
Leningrad.

Received
16.I.1945.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1945. Volume XLVIII, № 9

HELMINTHOLOGY

A CONTRIBUTION TO THE KNOWLEDGE OF THE BIOLOGICAL CYCLE OF *CAPILLARIA MUCRONATA* (MOLIN, 1858), A NEMATODE OF THE BLADDER OF SABLE, MARTEN AND MINK

By T. S. SKARBILOVICH

(Communicated by K. I. Skrjabin, Member of the Academy, 16. II. 1945)

Capillaria mucronata (Molin, 1858) is a nematode from the family *Capillariidae*, parasitic of the bladder of sable, mink, marten, polecat and stoat.

The nematode is widespread all over Western Europe. In the USSR it has first been discovered in several factories by Petrov in 1933 (²). It is of particularly frequent occurrence in the stoat and American mink.

The developmental cycle of *Capillaria mucronata* has still remained unstudied. A number of studies on the biology of *Capillariidae* published during the last few years went to demonstrate that th development of certain species of this family proceeds without the participation of an intermediary host, while others require for their development an intermediary host, the part of which is played by earthworms.

Borovkova (¹) succeeded in deciphering the developmental cycle of a helminth, parasitic of the lungs of fur animals, *viz. Thominx aerophilus*, which also belongs to the *Capillariidae* family; she discovered that this nematode developed under participation of earthworms as intermediary hosts.

Petrov and Borovkova (³) deciphered the biological cycle of the causative agent of capillariosis of the bladder in *Carnivora*, *viz.* of the nematode *Capillaria plica* (Rudolphi, 1819). In the course of this study these authors discovered the participation in the developmental cycle of *C. plica* of intermediary hosts, which were earthworms in this case, too.

The present author undertook experiments on direct infestation, and also experiments aiming at the establishment of the intermediary hosts for C. *mucronata*. For experiments on direct infestation eggs of *Capillariidae* were cultivated on agar plates; when kept at a temperature of 25° C, the eggs attained the invasional stage after some 34—36 days.

Two sables, two martens, four minks and one kitten received along with their feed invasional eggs of *C. mucronata*. The excreta of the animals were regularly examined, and none of them was found to eliminate eggs of *C. mucronata*.

After this we proceeded to experiments with earthworms which were transferred for a period of 1—5 days to agar plates containing invasional eggs of *C. mucronata*. When dissected, the worms were found to contain larvae of the parasite, which were located in their body cavity between two layers of muscles. During the summer season the larvae attained their invasional stage within 30—43 days in the bodies of earthworms. Under laboratory conditions, when kept in earthworms at a temperature of 25° C, they attained invasional stage after 20—25 days.

The development of larvae of *C. mucronata* was observed in the organism of two species of earthworms, viz. *Lumbricus rubellus* and *Lumbricus* sp.

In order fully to disclose the entire developmental cycle of *Capillaria mucronata*, *i. e.* to obtain adult forms within the organism of the definitive host, we experimentally infested with invasional eggs one sable, one marten, five minks and one kitten. In the course of subsequent examination, the sable and the marten were found to eliminate eggs of *C. mucronata* 42—45 days upon infestation. The minks were sacrificed towards the 24th and 34th day after being given invaded earthworms. When autopsied they were found to contain in their bladders both males and females of *C. mucronata* at an early developmental stage, sex immature, thin, transparent, and also females more advanced in their development, with ready eggs. The six control minks were found to contain no young forms of *C. mucronata*, but only old, degenerate parasites, devoid of eggs. The kitten proved uninfested.

The results of the experimental work here reported make it evident that the developmental cycle of the causative agent of capillariosis of the bladder in sable, marten and mink, *Capillaria mucronata*, proceeds under the participation of earthworms as intermediary hosts.

The total developmental cycle of the nematode *C. mucronata*, from the eggs and up to the production of eggs by the sex-mature worm, when taking place under the participation of earthworms, covers a period of about 100—120 days during the summer season. Under laboratory conditions, at a higher temperature, a higher rate of development of the nematode may be attained, and the cycle may be complete within 80—100 days.

Whilst studying the course of the capillariosis of the bladder in sable and American mink we became aware of the fact that the total lifetime of *Capillaria mucronata* does never exceed 12—14 months.

The All-Union K. I. Skrjabin
Institute of Helminthology.

Received
16.II.1945.

REFERENCES

[1] A. M. Borovkova, C. R. Acad. Sci. URSS, XXXI, No. 8 (1941). [2] А. М. Петров, Глистные болезни пушных зверей, М., 1941. [3] A. M. Petrov and A. M. Borovkova, C. R. Acad. Sci. URSS, XXXV, No. 5 (1942).

Juillet—Septembre

COMPTES RENDUS

(DOKLADY)

DE L'ACADÉMIE DES SCIENCES DE L'URSS

COMITÉ DE RÉDACTION

A. Arbusov, de l'Académie, **V. Chlopin,** de l'Académie, **A. Deborin,** de l'Académie, **A. Frumkin,** de l'Académie, **A. Kolmogoroff,** de l'Académie (vice rédacteur), **L. Orbeli,** de l'Académie (rédacteur en chef), **A. Richter,** de l'Académie, **S. Soboleff,** de l'Académie, **S. Vavilov,** de l'Académie (vice rédacteur)

NOUVELLE SÉRIE

13-me année

1945

VOLUME XLVIII

INDICE SYSTÉMATIQUE

S. I. Vavilov, President of the Academy 227

MATHÉMATIQUES

Vekua. I. N. Sur un certain développement des fonctions métaharmoniques 3

Tchounikhine S. A. On the Theory of Non-Associative n-Groups Satisfying Postulate K 7

Schaginjan A. Remarques sur l'approximation par les fonctions rationnelles dans un domaine complexe. II 11

Lifshitz I. M. On the Theory of Regular Perturbations 79

Myshkis A. On the Existence of the Total Differential on the Boundary of a Plane Domain 82

Busheguennce S. S. La géométrie d'un champ de vecteurs 156

Sarymsakov T. A., de l'Académie des Sciences d'Usbekistan. Sur une synthèse des deux méthodes d'exposer la théorie des chaînes discrètes de Markoff 159

Wagner V. Geometry of Field of Local Curves in X_3 and the Simplest Case of Lagrange's Problem in the Calculus of Variations . . . 229

Chogoshvili G. On the Duality Law in Normal Spaces 233

Krein M. On Self-adjoint extensions of Bounded and Semi-bounded Hermitian Transformations . . 303

Norden A. On Weyl's Projectively Euclidean Space 307

Sarymsakov T. A., de l'Académie des Sciences d'Uzbekistan. Généralisation des théorèmes de R. Jentzsch et F. Gantmacher 309

Busheguennce S. S. La géométrie du champ de vecteurs. II. 379

Wagner V. Geometry of Field of Local Central Plane Curves in X_3 . . . 382

Stepanoff W. Sur quelques systèmes non-orthogonaux 385

Fedoroff W. S. Sur la monogénéité . 389

Kantorovitch L. B. On an Effective Method of Solving Extremal Problems for Quadratic Functionals . 455

Neuschuler L. On Tabulating a Class of Inexplicit Functions of Four Variables 461

Kondrachoff W. Sur certaines propriétés des fonctions dans l'espace . 535

Norden A. The Affine Connectivity on the Surface of a Projective and Conformal Space 539

Soboleff S. L., de l'Académie. Sur la

presque périodicité des solutions de l'équation des ondes. I. . . . 542
Iegudin G. Parameters of Distribution of a Random Variable Invariant under Translations, and Algebraic Semi-invariants . . . 615
Soboleff S. L., de l'Académie. Sur la presque périodicité des solutions de l'équation des ondes. II . . . 618

MÉCANIQUE

Kreines M. Diagram of Angular Velocity Ratios of a Regular Toothed Gear Mechanism with Three Degrees of Freedom 162
Targ S. M. Damping of the Rotation of a Projectile in Piercing a Viscous Medium 236
Kreines M. Determination of the Efficiency of a Toothed-gear Mechanism with many Degrees of Freedom 465
Konakov P.K. Experiment in the Application of the Theory of Similarity to Investigation of the Working Process in the Steam-Engine of a Locomotive 545

AÉRODYNAMIQUE

Feinsilber A. M. Fundamental Problems of Fluid Dynamics for Boundary Layer on Airplane Wing . 86
Belenky S. Z. Condensational Jumps . 165
Voronin V. N. The Physics of Turbulent Flows. Differential Equations for the Motion of Steady-turbulence Flow. Similarity . . . 469

HYDRODYNAMIQUE

Wedernikow V. V. Conditions at the Front of a Translation Wave Disturbing a Steady Motion of a Real Fluid 239
Staniukovich K. P. On Automodel Solutions of Equations of Hydrodynamics Possessing Central Symmetry 310

HYDROMÉCANIQUE

Feinsilber A. M. Universal Variables in the Boundary Layer Theory . 473

HYDRAULIQUE

Trebin F. A., Khristianovich S. A., Member of the Academy, and **Chernikin V. I.** Isothermal Flow of Gas in Tubes with a Rough Surface 621

GÉODÉSIE

Kazinsky V. A. On the Application of Curvatures 622

PHYSIQUE MATHÉMATIQUE

Herman B. Theorems of the Theory of Anisotropic Media 89
Mayantz L. S. Perturbation Method with the Application of Double Iteration 313
Scherman D. I. On Diffraction of Elastic Waves 626

PHYSIQUE

Gorbunova K. M. and **Dankov P. D.** Elementary Electrocrystallization Processes 51
Vuks M. F. On the Structure of the Principal Scattering Line and the Nature of Continuous Radiation . 93
Semenchenko V. K. On the Determination of the Free Surface Energy of Crystals 96
Laemmlein G. G. Geometrical Selection in a Growing Crystal Aggregate 166
Feld J. N. Initial Boundary Problems of Electrodynamics. 172
Yavorsky B. Stepped Excitation of Mercury by Electronic Impact . 176
Herman V. L. Intercombinational Transitions in the Spectra of Complex Molecules 243
Godnev I. On the Determination of Nuclear Spin-function Symmetry in a Molecule. II. 247
Shafranovsky I. I. The Number of Structural Varieties in the Simple Form of Crystals 317
Adirovich E. Oscillation and Relaxation Processes in the Electron Plasma of the Discharge 551
Meshcheriakov M. G. An Absorption of Fast Neutrons by Heavy Nuclei . 555
Adirovich E. Propagation of Waves and Retardation of Electron Beams in Plasma 630
Wul B. M., Corresponding Member of the Academy, and **Wereshchaguin L. F.** Dependence of the Dielectric Permeability of Barium Titanate upon the Pressure . . . 634

OCÉANOLOGIE

Stockmann W. B. Characteristics of the Spreading of Atlantic Waters in the Polar Basin 18
Zenkovich V. P. Formation of Accumulative Forms along with Changes in the Direction of the Fundamental Shoreline. 322
— Differences between Accumulative and Abrasional Shoreline Profiles 395

PHYSIQUE BIOLOGIQUE

Kravkov S. V. and **Galochkina L. P.** Colour Vision as Affected by Electrotonus 20
Pinegin N. I. The Curve of Absolute Photopic Sensitivity of the Eye in the Region from 300 to 950 mμ . 249
Iiyna A. A., Ravikovich Kh. M., Rubinstein D. L. and **Shpolsky E. V.** Absorption Spectrum of Haemoglobin in Solution and in a Suspension of Red Blood corpuscles 325

Lifshitz S. J. Sensation Elements for Hearing and Touch. 479
Gurewitsch M. M. Spectrum Sensitivity of the Three Receptors of the Eye 637

PHYSIQUE APPLIQUÉE

Fürstenberg A. I. Electric Precision Measurements by Means of Incandescent Lamp Used as Indicator of Current Equality in two Circuits 23
Falkova O. B. Spectrum Analysis of Metals by the Powder Method and the Determination of Small Concentrations of Boron in Steels . . 179
Blank O. V. and **Sventitsky N. S.** Spectroscopic Determination of Carbon in Iron and Steel 252
Brekhovskikh L. M. Propagation of Sound Waves in a Liquid Layer Between Two Absorbing Half-spaces 307
Feld J. N. The General Theorem of Reciprocity in the Theory of Receiving and Transmitting Antennae 476
Friedman J. B. and **Volodina T. A.** On the Strength and Ductility of Quenched and Tempered Steel . 559
Kitaigorodsky I. I. Electron Microscope and Investigation of the Structure of Ceramic Materials . 563

CHALEUR

Charny I. A. On a Modification of Forchheimer's Problem 27
Chukhanov Z. F., Corresponding Member of the Academy. Heat Exchange between a Plate and a Flow of Gas Moving past it in Longitudinal Direction 100

ÉLECTRICITÉ

Sviridenko P. A. Substitution Diagrams for Transient Regimes of Asynchronous Electric Machines . 401

CHIMIE

Ivanov K. I. and **Savinova V. K.** Decahydronaphthalene Peroxide . 31
Korshak V. V. and **Rafikov S. R.** The Products of Linear Condensation of Diamines with Dicarboxylic Acids 35
Volstein L. M. A Dinuclear Internal Complex Salt of Chromium and Glycine and its Split Products . 105
Danilov V. P. The Spectral Absorption of Coloured Phosphate Glasses as a Function of their Structure . . 110
Bergman A. G. and **Dergunov E. P.** Fusion Diagram for the System KF—NaF—MgF_2 329
Černjaiev I. I., Member of the Academy, and **Rubinstein A. M.** A New Method of Producing Spectral-pure Platinum 332
Ivanov V. I. and **Kaverzneva E. D.** Chemical Changes which Take Place in the Cellulose Macromolecule in Copper-Ammonia Solution under the Action of Atmospheric Oxygen 405
Balandin A. A., Corresponding Member of the Academy, and **Marukjan G. M.** Production of Methyl Styrene of Catalytic Dehydrogenation of Isopropyl Benzene . . . 482
Goldfarb J. L. and **Kondakova M. S.** On the Action of Alkyl Halides on Amino-derivatives of Nicotine . 484
Zimakov P. V. et **Pokrovsky V. A.** Transformation catalytique de l'alcool allylique en acroléine par oxydation 641

CHIMIE PHYSIQUE

Zhdanov G. S. The Numeral Symbol of Close Globular Packing and its Application in the Packing Theory 39
— and **Minervina Z. V.** Analysis of the Crystal Structure SiCV (51-layered Packing) 182
Minz Z. L. and **Akimov G. V.,** Corresponding Member of the Academy. The Structure of Heat-resistant Austenite Steel. The Kinetics of Grain Growth and the Solution of Carbides in El-69 Steel upon Heating 185
Ratner S. B. Contribution to the Computation of the Characteristics of a Detonation Wave Propagated as a Stationary Wave through Condensed Explosives and the Equation of State for the Products of Explosion. 187
Belayev A. F. and **Chariton J. B.** The Limit Diameter of a Charge of Ammonium Nitrate 256
Derjaguin B. and **Pichuguin E.** A Needle Profilometer Study of the Oiliness of Lubricants 259
Kapustinsky A. F., Corresponding Member of the Academy. Entropies of Crystals at Infinitely High Pressures 263
Namiot A. J., Diatkina M. E. and **Syrkin J. K.,** Corresponding Member of the Academy. The Energy of Quinoid Forms. 267
Lipatov S. M., Member of the Academy of Sciences of the Belorussian SSR. The Thermodynamic Properties of High Polymers 409
Emanuel N. M. The Phenomenon Contraction and its Application in Chemical Kinetics 488
Akimov G. V., Corresponding Member of the Academy, and **Mintz Z. L.** Structure of Austenitic Heat-resistant Steel. Processes Involved in the Aging of Hardened El-69 Steel 565
Andreyev K. K. and **Bakeyev A. P.** On the Dependence of the Burning Velocity of Smokeless Powders upon the Pressure 567
Akulov N. S., Member of the Academy of Sciences of the Belorussian

SSR. On the Relation between the Induction Period and the Chemism of a Reaction 644

CHIMIE DU GLOBE

Guliaeva L. An Attempt to Correlate the Oils and Bitumens of the Ural-Volga Region According to Microelements 43
Maliuga D. P. Content of Copper, Nickel, Cobalt and Other Elements of the Iron Family in Native Waters 113
Yarzhemsky J. J. Potassium Salts of the Inder Uplift 191
Konshin V. D. Metamorphization of Water of Lake Balkhash 334
Siniakova S. I. On the Content of Lead in Plants 414
Dzens-Litovsky A. I. Natural Gases of Bottom Deposits of Mineral Lakes 491
Siniakova S. I. On the Distribution of Lead in Soils 648

CHIMIE BIOLOGIQUE

Gurewitsch A. A. On the Reduction of Ortho-dinitrobenzene in Green Plants. On the Theory of Regulation of Protein Exchange in Plants 117
Ivanov I. I. and **Umanskaya M. V.** Chemical Transformations as a Source of Energy for the Mobility of *Trupanosoma equiperdum* . . 337
Anisimova V. A. Certain biochemical features peculiar to the fungus *Verticillium dahliae* Klebahn . . 416
Blagoveshchensky A. V. and **Kologrivova A. J.** Activation of Catalase by Biogenic Stimulants 571
Fedorov M. V. Chemical Basis of Fixation of Atmospheric Nitrogen by *Azotobacter* 575
Passynsky A. and **Plaskeyev V.** Diffusion and Molecular Weight of Lysozyme 579
Maximov N. A., Corresponding Member of the Academy, **Rakitin J. V.** and **Turezkaya R. Kh.** A Procedure Ensuring the Preservation of Vitamin C in Leaves of Gladiolus Prepared for Storage 651
Zepkova G. A. Concentration of Vitamin C in Certain Plant Species of Central Asia 655

CHIMIE APPLIQUÉE

Griaznov V. M., Korobov V. V. and **Frost A. V.** Nature of Active Centres of Alumosilicate Catalysts . 339
Budnikov P. P., Corresponding Member of the Academy, and **Butt K. M.** Effect of Coal Ash Enriched with Lime upon Hydration of Insoluble Anhydrite 420
Avgustinik A. I. and **Ushakova E. F.** On Kinetics of Formation of Mullite in Clay Materials upon Burning 494

GÉOLOGIE

Ermakov N. P. The Genetic Types of Crystal-bearing «Cellars» and Quartz Veins of Aldan 46
Mikhailov P. P. The Murzhik Deposit of Manganese Ores 50
Pospelov L. G. A Structural Classification of Eluvium 121
Suleimanov I. S. Some New Species of Small Foraminifers from the Tournaisian of the Ishimbayevo Oil-bearing Region 124
Illarionov I. K. A Contribution to the Geochemistry of Hydrogen Sulphide of the near-Volga Zone of the Sviyaga-Sura Divide 193
Ivantishin M. N. On the Primary Regional Zoning of Ore Deposits of the Northern Part of the East-Asiatic Pacific Folded Region . 270
Moör G. On the Spar-bearing Province of the Siberian Trap Region . . 423
Sobolev D. N. and **Shkabara M. N.** The Sinevka Salt Dome and its Geological Place 427
Kropotkin P. N. A New Region of Tungsten and Molybdenum Mineralization in North-eastern Kazakhstan 496
Ronov A. B. The Geology of the Leaching Processes in the Lower Permian to the Carbonate-Sulphate Series of the Chistopol Uplifts . . 498
Pavlovsky E. V. and **Semiguzov G. K.** Quaternary Glaciation of the Sunnaghin Range (South Yakutia) . 582
Solovkin A. N. New Data on the Occurrence of Ores in the Intrusion of the Little Caucasus (Azerbaidjan SSR) 585
Zlatkind C. G. The Kovdoro-lake Pluton of Alkaline and Ultrabasic Rocks 659
Polkanov A. A., Member of the Academy. The Principal Theses of the Genetic Systematics of Intrusive Bodies 662
Saks V. N. Kaolins in the North of the West-Siberian Lowlands and their Significance for the Knowledge of the Structure of the Region . . . 666

HYDROGÉOLOGIE

Zonn S. V. Chemical Composition of Ground Waters as Dependent on Soil Formation 197
Ronov A. B. Hydrogeology of Carboniferous Deposits of the Volga Area 343

MINÉRALOGIE

Sidorenko A. V. Mitridatites from Kerch and the Taman Peninsuls . 53
Barsanov G. P. Ampangabeite from the Yelisseyevka Deposit (Ukrainian SSR). 128
Aprodova A. A. Thermonatrite in the near-Kama Region 274
Pewzner R. L. New Data on the Refractoriness of Artik Tuff Lava . 276

Aprodov V. A. Blue Halite from the Solikamsk Potassium Deposits . 346
Vardanjanz L. A. Birefringence of any Random Section of an Optic Indicatrix 349
Filonenko N. E. On Some High-alumina Minerals in a Block of Electrocorundum 430
Kostyleva E. E. Zirfesite, a New Zirconium Mineral of the Zone of Hypergenesis 502
Kuznetzov A. M. and **Prochukhan D. P.** On the Formation of Columnar Calcite 587
Renngarten N. V. A Zeolite from the Mordenite Group in the Upper Cretaceous and Palaeogene Marine Deposits of the Eastern Slope of the Urals 591

PALÉONTOLOGIE

Vialov S. V. New Oysters from the Palaeogene of the Trans-Caspian Region 200
Yakovlev N. N., Corresponding Member of the Academy. On Bryozoan and Crinoidal Reefs of the Permian Period in the Urals . . 352
— Primary Factors in the Development of the Corals *Zoantharia* . . 434
Vialov O. S. *Lopha nophertiti* sp. n. from the Upper Cretaceous of Turkmenia 505

HISTOLOGIE

Anikin A. V. Histophysiology of the Mesothelium of the Serosa of Spleen and Testis 509

GÉNÉTIQUE

Perlova R. L. Production at Pamir of the Original Species of the Chile Autotriploid *Solanum maglia* Schlechtd 56
Poddubnaya-Arnoldi V. A Contribution to the Chromosome Morphology of Hard Wheat 278
Sinskaya E. N. On the Diploid Species of Yellow Alfalfa 281
Svetlov P. G. Susceptibility of Intestine Epithelium in Males and Females of *Drosophila melanogaster* to the Noxious Effect of Lactic Acid 355

ÉCOLOGIE

Oliphan V. I. Influence of Salinity on the Eggs of *C. orgonus migratorius* Georgi 59
Ponomarev A. N. On the Relatively Narrow Range of Distribution of the Calcophytes of the Middle Urals as Connected with their Relict Nature 204
Fedotov D. M. Response of Imago of *Eurygas er in egriceps* Put. to Certain Anabiotic Conditions . . . 283
Poplavska G. I. On Winter Respiration in Different Geographical Races of the Same Plant Species . 670
Sochava V. B. Ecological Relicts of Manchurian Flora Considered in Connexion with Certain Palaeogeographical Restorations 674

MICROBIOLOGIE

Kovalenok A. Sensitivity of *Paramaecium caudatum* to Toxic Agents at Various Stages of Ontogenesis . . 437
Yanovitch T. D. Influence of Phytoncides upon Paracholeraic Vibrios . 513

PHYSIOLOGIE VÉGÉTALE

Holubinsky I. N. Studies on the Physiology of the Germination of Pollen. I. Mutual Stimulation in the Germination of Pollen grains . 62
Ratner E. I. Interaction between Roots and Soil Colloids as a Problem of Mineral Nutrition of Plants. Rôle of the Root System 64
Bobko E. V. and **Vakushkina N. I.** A Gravimetrical Method for Determining the Activity of Growth Substances 132
Sokolov A. V. Transplantation as Applied to the Study of Nutrition of Different Plant Species 135
Čajlachjan M. Ch. and **Megrabjan A. A.** Effect of Soluble Nitrogenous Compounds upon Formation of Nodules on Roots of Leguminous Plants 138
Demidenko T. T. Effect of Granulated Superphosphate upon the Yield when Introduced with the Seeds . 207
Sukhorukov K. and **Strogonov B.** On the Effect of Heteroauxine upon Cells of Diseased Plant 210
Erygin P. S. Exchange in the Flooded Seedlings of Rice 286
Navashin M. S. and **Cherednichenko A. F.** A Field Method for Estimating Rubber Content in Live Roots of Rubber Plants 289
Bobko E. V. and **Priadilshchikova T. D.** On the Solubility of Boron Compounds in the Plant 358
Čajlachjan M. Ch. On the Correlation between the Reaction of Flowering to the Nitrogenous Food and the Photoperiodic Reaction of the Plant 360
Blagoveshchensky A. V. and **Kologrivova A. J.** Growth of Roots as Stimulated by Certain Organic Acids 440
Novikov V. A. Effect of Day-Length upon Salt-resistance in Cotton . 444
Bobko E. V. and **Priadilshchikova T. D.** Effect of Sodium Chloride upon the Yield of Oats in the Presence of Various Substances (Potassium Bicarbonate, Ashes, *etc.*) . . . 516
Prokofiev A. A. On the Synthesis of Rubber in Plants 520

PHYTOPATHOLOGIE

Vovk A. M. Mosaic on Leguminosae . 213
Sukhov K. S. and **Vovk A. M.** On the Identity between Yellow of Koksaghyz and Yellow of Aster and

its Possible Relation to Big Bud in Tomato 365
Nevskaya Z. L. Influence of Aphides upon Carbohydrate Exchange in Cotton 369

PHYSIOLOGIE

Shcheglova A. I. Variation in the Thermotaxis Optimum of Rodents as Dependent on Pregnancy . . . 524
Privolnev T. I. Skin Respiration in *Carassius carassius* 595
Shutova A. A. Phagocytic Activity of Leucocytes as Affected by Serums Containing Leucocytic Trephones 597

ENDOCRINOLOGIE

Wunder P. A. On the Influence of Estrogens upon the Thyrotropic Reaction 602

MORPHOLOGIE EXPÉRIMENTALE

Steinberg D. M. Regulation Processes in the Metamorphosis of Insects. Self-differentiation of the Wing in Butterflies 68
Vinnikov J. A. Explantation of the Rudiments of Skin Epidermis and Neural Plate 145
Katznelson Z. S. Influence of Lithium Chloride upon Histogenetic Processes in *Anura* 149
Poležajew L. W. Chemical Methods for Restoring the Regenerative Capacity of Limbs in Tadpoles . . . 216
Vinnikov J. A. Explanation of Neural Crests in *Amphibia* 293
Popov V. V. Induction of Tympanic Membrane in *Bombina bombina* and *Peloba us fuscus* 374
Lasarev N. I. On the Nature of the Inhibitory Effect of Lens upon Lens Regeneration in Triton . . 447
Zhinkin L. Regeneration of Extremities in *Periplaneta orientalis* 527
Lopashov G. V. On some Elementary Processes of Organization of Eye and Brain Anlages in Embryos of *Urodela* 605
Zhinkin L. Regeneration of Muscles in *Mammalia* 678

ZOOLOGIE

Popov V. V. Zoogeography and some Morphological Peculiarities of the *Trigonaloidae* Family (*Hymenoptera*) 72
Svetovidov A. N. *Chalcalburnus chalcoides iranicus* subsp. nova from the Caspian Coast of Iran, and some Zoogeographical Problems of the Southern Part of this Sea . 142
Teplyakova M. J. Comparative Data on the Development of Reproductive Organs in *Eurygaster integriceps* Put. in the Plain of the South of the USSR and in Uzbekistan . . 221
Ivanov A. V. A New Endoparasitic Mollusc *Parenterocxenos dogieli*, nov. gen., nov. sp. 450
Gussakovsky V. V. A New Genus of *Cephidae* (*Hymenoptera*) from Turkestan 530
Gershenson S. Seasonal Fluctuations in the Frequency of Black Hamsters 681
Stackelberg A. A. New Data on the Status of the Genus *Myennis* R. D. (*Diptera, Otitidae*) 684

PARASITOLOGIE

Nikolskaia M. N. Evolution of *Eurytoma* Species (*Hymenoptera, Chalcididae*) in Connexion with the Geographical Distribution of Their Food-plants of the subfam. *Prunoideae* 609

HELMINTHOLOGIE

K. I. Skrjabin, Member of the Academy. On the Taxonomic Position of *Haematotrephus fodiens* Linton, 1928, within the System of Trematodes 75
— and **Karokhin V. I.** On the Rearrangement of Nematodes of the Order *Ascaridaea* Skrjabin, 1915. 297
Skarbilovich T. S. A Contribution to the Knowledge of the Biological Cycle of *Capillaria mucronata* (Molin, 1858), a Nematode of the Bladder of Sable, Marten and Mink 687

INDICE ALPHABÉTIQUE

Adirovich E. Oscillation and Relaxation Processes in the Electron Plasma of the Discharge 551
— Propagation of Waves and Retardation of Electron Beams in Plasma. 630
Akimov G. V. and **Mintz Z. L.** Structure of Austenitic Heat-resistant Steel. Processes Involved in the Aging of Hardened El-69 Steel . 565
— voir **Mintz Z. L.** 185
Akulov N. S. On the Relation between the Induction Period and the Chemism of a Reaction 644
Andreyev K. K. and **Bakeyev A. P.** On the Dependence of the Burning Velocity of Smokeless Powders upon the Pressure 567
Anikin A. V. Histophysiology of the Mesothelium of the Serosa of Spleen and Testis 509
Anisimova V. A. Certain Biochemical Features Peculiar to the Fungus *Verticilium dahliae* Klebahn . 416
Aprodov V. A. Blue Halite from the Solikamsk Potassium Deposits . 346
Aprodova A. A. Thermonatrite in the near-Kama Region 274

Avgustinik A. I. and **Ushakova E. F.** On Kinetics of Formation of Mullite in Clay Materials upon Burning 494
Bakeyev A. P. voir **Andreyev K. K.** . 567
Balandin A. A. and **Marukjan G. M.** Production of Methyl Styrol of Catalytic Dehydrogenation of Isopropyl Benzene 482
Barsanov G. P. Ampangabeite from the Yelisseyevka Deposit (Ukrainian SSR) 128
Belayev A. F. and **Chariton J. B.** The Limit Diameter of a Charge of Ammonium Nitrate 256
Belenky S. Z. Condensational Jumps . 165
Bergman A. G. and **Dergunov E. P.** Fusion Diagram for the System KF—NaF—MgF_2 329
Blagoveshchensky A. V. and **Kologrivova A. J.** Activation of Catalase by Biogenic Stimulants 571
— Growth of Roots as Stimulated by Certain Organic Acids 440
Blank O. V. and **Sventitsky N. S.** Spectroscopic Determination of Carbon in Iron and Steel 252
Bobko E. V. and **Yakushkina N. I.** A Gravimetrical Method for Determining the Activity of Growth Substances 132
— and **Priadilshchikova T. D.** On the Solubility of Boron Compounds in the Plant 358
— Effect of Sodium Chloride upon the Yield of Oats in the Presence of Various Substances (Potassium, Bicarbonate, Ashes, *etc.*) . . . 516
Brekhovskikh L. M. Propagation of Sound Waves in a Liquid Layer between two Absorbing Half-spaces 307
Budnikov P. P. and **Butt K. M.** Effect of Coal Ash Enriched with Lime upon Hydration of Insoluble Anhydrite 420
Busheguennce S. S. La géométrie d'un champ de vecteurs 156
— La géométrie du champ de vecteurs. II. 379
Butt K. M. voir **Budnikov P. O.** . . . 420
Čajlachjan M. Ch. and **Megrabjan A. A.** Effect of Soluble Nitrogenous Compounds upon Formation of Nodules on Roots of Leguminous Plants 138
— On the Correlation between the Reaction of Flowering to the Nitrogenous Food and the Photoperiodic Reaction of the Plant . . . 360
Černjaiev I. I. and **Rubinstein A. M.** A New Method of Producing Spectral-pure Platinum 332
Chariton J. B. voir **Belayev A. F.** . . 256
Charny I. A. On a Modification of Forchheimer's Problem 27
Cherednichenko A. F. voir **Navashin M. S.** 289
Chernikin V. I. voir **Trebin F. A.** . 621
Chogoshvili G. On the Duality Law in Normal Spaces. 233
Chukhanov Z. F. Heat Exchange between a Plate and a Flow of Gas Moving past it in Longitudinal Direction 100
Danilov V. P. The Spectral Absorption of Coloured Phosphate Glasses as a Function of their Structure . . 110
Dankov P. D. voir **Gorbunova K. M.** . 15
Demidenko T. T. Effect of Granulated Superphosphate upon the Yield when Introduced with the Seeds . 207
Dergunov E. P. voir **Bergman A. G.** . 329
Derjaguin B. and **Pichugin E.** A Needle Profilometer Study of the Oiliness of Lubricants 259
Diatkina M. E. voir **Namiot A. J.** . . 267
Dzens-Litovsky A. I. Natural Gases of Bottom Deposits of Mineral Lakes 491
Emanuel N. M. The Phenomenon of Contraction and its Application in Chemical Kinetics 488
Ermakov N. P. The Genetic Types of Crystal-bearing «Cellars» and Quartz Veins of Aldan 46
Erygin P. S. Exchange in the Flooded Seedlings of Rice 286
Falkova O. B. Spectrum Analysis of Metals by the Powder Method and the Determination of Small Concentrations of Boron in Steels . . 179
Fedoroff W. S. Sur la monogénéité . . 389
Fedorov M. V. Chemical Basis of Fixation of Atmospheric Nitrogen by *Azotobacter* 575
Fedotov D. M. Response of Imago of *Eurygaster integriceps* Put. to Certain Anabiotic Conditions . . 283
Feinsilber A. M. Fundamental Problems of Fluid Dynamics for Boundary Layer on Airplane Wing . . 86
— Universal Variables in the Boundary Layer Theory 473
Feld J. N. Initial Boundary Problems of Electrodynamics 172
— The General Theorem of Reciprocity in the Theory of Receiving and Transmitting Antennae . . 476
Filonenko N. E. On Some High-alumina Minerals in a Block of Electrocorundum 430
Friedman J. B. and **Volodina T. A.** On the Strength and Ductility of Quenched and Tempered Steel . 559
Frost A. V. voir **Griaznov V. M.** . . . 339
Fürstenberg A. I. Electric Precision Measurements by Means of Incandescent Lamp Used as Indicator of Current Equality in two Circuits 23
Galochkina L. P. voir **Kravkov S. V.** . 20
Gershenson S. Seasonal Fluctuations in the Frequency of Black Hamsters 681
Godnev I. On the Determination of Nuclear Spin-function Symmetry in a Molecule. II. 247
Goldfarb J. L. and **Kondakova M. S.** On the Action of Alkyl Halides on Amino-derivatives of Nicotine 484
Gorbunova K. M. and **Dankov P. D.** Elementary Electrocrystallization Processes 15
Griaznov V. M., Korobov V. V. and **Frost A. V.** Nature of Active Centres of Allumosilicate Catalysts . 339

Guliaeva L. An Attempt to Correlate the Oils and Bitumens of the Ural-Volga Region According to Microelements 43
Gurewitsch A. A. On the Reduction of Ortho-dinitrobenzene in Green Plants. On the Theory of Regulation of Protein Exchange in Plants. 117
Gurewitsch M. M. Spectrum Sensitivity of the Three Receptors of the Eye. 637
Gussakovsky V. V. A New Genus of *Cephidae* (*Hymenoptera*) from Turkestan 530
Herman B. Some Theorems of the Theory of Anisotropic Media 89
— Intercombinational Transitions in the Spectra of Complex Molecules 243
Holubinsky I. N. Studies on the Physiology of the Germination of Pollen. I. Mutual Stimulation in the Germination of Pollen Grains . . 62
Iegudin G. Parameters of Distribution of a Random Variable Invariant under Translations, and Algebraic Semi-invariants 615
Illarionov I. K. A Contribution to the Geochemistry of Hydrogen Sulphide of the near-Volga Zone of the Sviyaga-Sura Divide 193
Iliyna A. A., Ravikovich Kh. M., Rubinstein D. L. and **Shpolsky E. V.** Absorption Spectrum of Haemoglobin in Solution and in a Suspension of Red Blood Corpuscles . . 325
Ivanov A. V. A New Endoparasitic Mollusc *Parenteroxenos dogieli*, nov. gen., nov. sp. 450
Ivanov I. I. and **Umanskaya M. V.** Chemical Transformations as a Source of Energy for the Mobility of *Trypanosoma equiperdum* . . 337
Ivanov K. I. and **Savinova V. K.** Decahydronaphthalene Peroxide . 31
Ivanov V. I. and **Kaverzneva E. D.** Chemical Changes which Take Place in the Cellulose Macromolecule in Copper-Ammonia Solution under the Action of Atmospheric Oxygen 405
Ivantishin M. N. On the Primary Regional Zoning of Ore Deposits of the Northern Part of the East-Asiatic Pacific Folded Region . 270
Kantorovitch L. B. On an Effective Method of Solving Extremal Problems for Quadratic Functionals . 455
Kapustinsky A. F. Entropies of Crystals at Infinitely High Pressures 263
Karokhin V. I. voir **Skrjabin K. I.** . 297
Katznelson Z. S. Influence of Lithium Chloride upon Histogenetic Processes in Anura 149
Kaverzneva E. D. voir **Ivanov V. I.** . 405
Kazinsky V. A. On the Application of Curvatures 622
Khristianovich S. A. voir **Trebin F. A.** 621
Kitaigorodsky I. I. Electron Microscope and Investigation of the Structure of Ceramic Materials . 563
Kologrivova A. J. voir **Blagoveshchensky A. V.** 440,571
Konakov P. K. Experiment in the Application of the Theory of Similarity to Investigation of the Working Process in the Steam-Engine of a Locomotive 546
Kondakova M. S. voir **Goldfarb J. L.** . 484
Kondrachoff W. Sur certaines propriétés des fonctions dans l'espace . . 535
Konshin V. D. Metamorphization of Water of Lake Balkhash 334
Korobov V. V. voir **Griaznov V. M.** . 339
Korshak V. V. and **Rafikov S. R.** The Products of Linear Condensation of Diamines with Dicarboxylic Acids 35
Kostyleva E. E. Zirfesite, a New Zirconium Mineral of the Zone of Hypergenesis 502
Kovalenok A. Sensitivity of *Paramaecium caudatum* to Toxic Agents at Various Stages of Ontogenesis . . 437
Kravkov S. V. and **Galochkina L. P.** Colour Vision as Affected by Electrotonus 20
Krein M. On Self-adjoint Extensions of Bounded and Semi-bounded Hermitian Transformations . . 303
Kreines M. Diagram of Angular Velocity Ratios of a Regular Toothed-Gear Mechanism with Three Degrees of Freedom 162
— Determination of the Efficiency of a Toothed-Gear Mechanism with many Degree of Freedom 465
Kropotkin P. N. A New Region of Tungsten and Molybdenum Mineralization in North-eastern Kazakhstan 496
Kuznetzov A. M. and **Prochukhan D. P.** On the Formation of Columnar Calcite 587
Laemmlein G. G. Geometrical Selection in a Growing Crystall Aggregate 166
Lasarev N. I. On the Nature of the Inhibitory Effect of Lens upon Lens Regeneration in Triton . . 447
Lifshitz I. M. On the Theory of Regular Perturbations 79
Lifshitz S. J. Sensation Elements for Hearing and Touch 479
Lipatov S. M. The Thermodynamic Properties of High Polymers . . 409
Lopashov G. V. On some Elementary Processes of Organization of Eye and Brain Anlages in Embryos of *Urodela* 605
Maliuga D. P. Content of Copper, Nickel, Cobalt and Other Elements of the Iron Family in Native Waters 113
Marukjan G. M. voir **Balandin A. A.** . 482
Maximov N. A., Rakitin J. V. and **Turezkaya R. Kh.** A Procedure Ensuring the Preservation of Vitamin C in Leaves of Gładiolus Prepared for Storage 651
Mayantz L. S. Perturbation Method with the Application of Double Iteration 313
Megrabjan A. A. voir **Čajlachjan M. Ch.** 138
Meshcheriakov M. G. An Absorption of Fast Neutrons by Heavy Nuclei . 555

Mikhailov P. P. The Murzhik Deposit of Manganese Ores 50
Minervina Z. V. voir Zhdanov G. S. . 182
Mintz Z. L. and **Akimov G. V.** The Structure of Heat-resistant Austenite Steel. The Kinetics of Grain Growth and the Solution of Carbides in El-69 Steel upon Heating. 185
— voir **Akimov G. V.** 185,565
Moör G. On the Spar-bearing Province of the Siberian Trap Region . . 423
Myshkis A. On the Existence of the Total Differential on the Boundary of a Plane Domain 82
Namiot A. J., Diatkina M. E. and **Syrkin J. K.** The Energy of Quinoid Forms 267
Navashin M. S. and **Cherednichenko A. F.** A Field Method for Estimating Rubber Content in Live Roots of Rubber Plants 289
Neuschuler L. On Tabulating a Class of Inexplicit Functions of Four Variables 461
Nevskaya Z. L. Influence of Aphides upon Carbohydrate Exchange in Cotton 369
Nikolskaya M. N. Evolution of *Eurytoma* Species (*Hymenoptera, Chalcididae*) in Connexion with the Geographical Distribution of Their Food-plants of the subfam. *Prunoideae* 609
Norden A. On Weyl's Projectively Euclidean Space 307
— The Affine Connectivity on the Surface of a Projective and Conformal Space 539
Novikov V. A. Effect of Day-length upon Salt-Resistance in Cotton . 444
Oliphan V. I. Influence of Salinity on the Eggs of *Corgonus migratorius* Georgi. 59
Passynsky A. and **Plaskeyev V.** Diffusion and Molecular Weight of Lysozyme 579
Pavlovsky E. V. and **Semiguzov G. K.** Quaternary Glaciation of the Sunnaghin Range (South Yakutia) . 582
Perlova R. L. Production at Pamir of the Original Species of the Chile Autotriploid *Solanum maglia* Schlechtd. 56
Pewzner R. L. New Data on the Refractoriness of Artik Tuff Lava . 276
Pichugin E. voir **Derjaguin B.** 259
Pinegin N. I. The Curve of Absolute Photopic Sensitivity of the Eye in the Region from 300 to 950 mμ . 249
Plaskeyev V. voir **Passynsky A.** . . . 579
Poddubnaya-Arnoldi V. A Contribution to the Chromosome Morphology of Hard Wheat 278
Pokrovsky V. A. voir **Zimakov P. V.** . 641
Poležajew L. W. Chemical Methods for Restoring the Regenerative Capacity of Limbs in Tadpoles . . . 216
Polkanov A. A. The Principal Theses of the Genetic Systematics of Intrusive Bodies 662
Ponomarev A. N. On the Relatively Narrow Range of Distribution of the Calcophytes of the Middle Urals as Connected with their Relict Nature 204
Poplavska G. I. On Winter Respiration in Different Geographical Races of the Same Plant Species . 670
Popov V. V. Induction of Tympanic Membrane in *Bombina bombina* and *Pelobatus fuscus* 374
— Zoogeography and some Morphological Peculiarities of the *Trigonaloidae* Family (*Hymenoptera*) . 72
Pospelov L. G. A Structural Classification of Eluvium 121
Priadilshchikova T. D. voir **Bobko E. V.** 358
Privolnev T. I. Skin Respiration in *Carassius carassius* 595
Prochukhan D. P. voir **Kuznetzov A. M.** 587
Prokofiev A. A. On the Synthesis of Rubber in Plants 520
Rafikov S. R. voir **Korshak V. V.** . . 35
Rakitin J. V. voir **Maximov N. A.** . . 651
Ratner E. I. Interaction between Roots and Soil Colloids as a Problem of Mineral Nutrition of Plants. Rôle of the Root System 64
Ratner S. B. Contribution to the Computation of the Characteristics of a Detonation Wave Propagated as a Stationary Wave through Condensed Explosives and the Equation of State for the Products of Explosion 187
Ravikovich Kh. M. voir **Iliyna A. A.** . 325
Renngarten N. V. A Zeolite from the Mordenite Group in the Upper Cretaceous and Palaeogene Marine Deposits of the Eastern Slope of the Urals 591
Ronov A. B. The Geology of the Leaching Processes in the Lower Permian to the Carbonate-Sulphate series of the Chistopol Uplifts . 498
— Hydrogeology of Carboniferous Deposits of the Volga Area . . . 343
Rubinstein A. M. voir **Černjaiev** . . 332
Rubinstein D. L. voir **Iliyna A. A.** . . 325
Saks V. N. Kaolins in the North of the West-Siberian Lowlands and their Significance for the Knowledge of the Structure of the Region . . 666
Sarymsakov T. A. Généralisation des théorèmes de R. Jentzsch et F. Gantmacher 309
— Sur une synthèse de deux méthodes d'exposer la théorie des chaînes discrètes de Markoff 159
Savinova V. K. voir **Ivanov K. I.** . . 31
Schaginjan A. Remarques sur l'étude de l'approximation par les fonctions rationnelles dans un domaine complexe. II 11
Scherman D. I. On Diffraction of Elastic Waves 626
Semenchenko V. K. On the determination of the Free Surface Energy of Crystals 96
Semiguzov G. K. voir **Pavlovsky E. V.** 582
Shafranovsky I. I. The Number of Structural Varieties in the Simple Form of Crystals 317

Shcheglova A. I. Variation in the Thermotaxis optimum of Rodents as Dependent on Pregnancy . 524
Shkabara M. N. voir **Sobolev D. N.** . . 325
Shutova A. A. Phagocytic Activity of Leucocytes as Affected by Serums Containing Leucocytic Trephones. 597
Sidorenko A. V. Mitridatites from Kerch and the Taman Peninsula . 53
Siniakova S. J. On the Content of Lead in Plants 414
— On the Distribution of Lead in Soils 648
Sinskaya E. N. On the Diploid Species of Yellow Alfalfa 281
Skarbilovich T. S. A Contribution to the Knowledge of the Biological Cycle of *Capillaria mucronata* (Molin, 1858), a Nematode of the Bladder of Sable, Marten and Mink 687
Skrjabin K. I. On the Taxonomic Position of *Haematotrephus fodiens* Linton, 1928, within the System of Trematodes 75
— and **Karokhin V. I.** On the Rearrangement of Nematodes of the Order *Ascaridaea* Skrjabin, 1915 . . . 297
Soboleff S. L. Sur la presque périodicité des solutions de l'équation des ondes. I 542
— Sur la presque périodicité des solutions de l'équation des ondes. II . 618
Sobolev D. N. and **Shkabara M. N.** The Sinevka Salt Dome and its Geological Place 618
Sochava V. B. Ecological Relicts of Manchurian Flora Considered in Connexion with Certain Polaeogeographical Restorations . . . 675
Sôkolov A. V. Transplantation as Applied to the Study of Nitrition of Different Plant Species 135
Solovkin A. N. New Data on the Occurrence of Ores in the Intrusion of the Little Caucasus (Azerbaidjan SSR) 58
Stackelberg A. A. New Data on the Status of the Genus *Myennis* R. D. (*Diptera, Otitidae*) 684
Staniukovich K. P. On Automodel Solutions of Equations of Hydrodynamics Possessing Central Symmetry 30
Steinberg D. M. Regulation Processes in the Metamorphosis of Insects. Self-Differentiation of the Wing in Butterflies 68
Stepanoff W. Sur quelques systèmes non-orthogonaux 385
Stockmann W. B. Characteristics of the Spreading of Atlantic Waters in the Polar Basin 18
Strogonov B. voir **Sukhorukov K.** . . 210
Sukhorukov K. and **Strogonov B.** On the Effect of Heteroauxine upon Cells of Diseased Plant 210
Sukhov K. S. and **Vovk A. M.** On the Identity between Yellow of Koksaghyz and Yellow of Aster and its Possible Relation to Big Bud in Tomato 365
Suleimanov I. S. Some New Species of Small Foraminifers from the Tournaisian of the Ishimbayevo Oil-bearing Region 124
Sventitsky N. S. voir **Blank O. V.** . . 252
Svetlov P. G. Susceptibility of Intestine Epithelium in Males and Females of *Drosophila melanogaster* to the Noxious Effect of Lactic Acid 355
Svetovidov A. N. *Chalcalburnus chalcoides iranicus* subsp. nova from the Caspian Coast of Iran, and some Zoogeographical Problems of the Southern Part of this Sea . 142
Sviridenko P. A. Substitution Diagrams for Transient Regimes of Asynchronous Electric Machines. 401
Syrkin J. K. voir **Namiot A. J.** . . . 267
Targ S. M. Damping of the Rotation of a Projectile in Piercing a Viscous Medium 236
Tchounikhine S. A. On the Theory of Non-Associative n-Groups Satisfying Postulate K. 7
Teplyakova M. J. Comparative Data on the Development of Reproductive Organs in *Eurygaster integriceps* Put. in the Plain of the South of the USSR and in Uzbekistan 221
Trebin F. A., Khristianovich S. A. and **Chernikin V. I.** Isothermal Flow of Gas in Tubes with a Rough Surface 621
Turezkaya R. Kh. voir **Maximov N. A.** 651
Umanskaya M. V. voir **Ivanov I. I.** . 337
Ushakova E. F. voir **Avgustinik A. I.** . 494
Vardanjanz L. A. Birefringence of any Random Section of an Optic Indicatrix 349
Vekua I. N. Sur un certain développement des fonctions métaharmoniques 3
Vialov S. V. New Oysters from the Palaeogene of the Transcaspian Region 200
— *Lopha nophertiti* sp. n. from the Upper Cretaceous of Turkmenia . 505
Vinnikov J. A. Explantation of the Rudiments of Skin Epidermis and Neural Plate 145
— Explantation of Neural Crests in *Amphibia* 293
Volodina T. A. voir **Friedman J. B.** . 559
Volstein L. M. A Dinuclear Internal Complex Salt of Chromium and Glycine and its Split Products . 105
Voronin V. N. The Physics of Turbulent Flows. Differential Equations for the Motion of Steady-turbulence Flow. Similarity 469
Vovk A. M. Mosaic on *Leguminosae* . 213
— voir **Sukhov K. S.** 365
Vuks M. F. On the Structure of the Principal Scattering Line and the Nature of Continuous Radiation . 93
Wagner V. Geometry of Field of Local Curves on X_3 and the Simplest Case of Lagrange's Problem in the Calculus of Variations . . . 229

— Geometry of Field of Local Central Plane Curves in X_3 382
Wedernikov V. V. Conditions at the Front of a Translation Wave Disturbing a Steady Motion of a Real Fluid 239
Wereshchagin L. F. voir **Wul B. M.** . 634
Wul B. M. and **Wereshchagin L. F.** Dependence of the Dielectric Constant of Barium Titanate upon the Pressure 634
Wunder P. A. On the Influence of Estrogens upon the Thyrotropic Reaction 602
Yakovlev N. N. On Bryozoan and Crinoidal Reefs of the Permian Period in the Urals 352
— Primary Factors in the Development of the Corals *Zoantharia* . . 434
Yakushkina N. I. voir **Bobko E. V.** . . 132
Yanowitch T. D. Influence of Phytoncides upon Paracholeraic Vibrios . 513
Yarzhemsky J. J. Potassium Salts of the Inder Uplift 191
Yavorsky B. Stepped Excitation of Mercury by Electronic Impact . 176
Zenkovich V. P. Formation of Accumulative Forms along with Changes in the Direction of the Fundamental Shoreline 322
— Differences between Accumulative and Abrasional Shoreline Profiles. 395
Zepkova G. A. Concentration of Vitamin C in Certain Plant Species of Central Asia 655
Zhdanov G. S. The Numeral Symbol of Close Globular Packing and its Application in the Packing Theory 39
— and **Minervina Z. V.** Analysis of the Crystal Structure SiCV (51-layered Packing) 182
Zhinkin L. Regeneration of Extremities in *Periplaneta orientalis* 527
— Regeneration of Muscles in *Mammalia* 678
Zimakov P. V. et **Pokrovsky V. A.** Transformation catalytique de l'alcool allylique en acroléine par oxydation 641
Zlatkind C. G. The Kovdoro-lake Pluton of Alkaline and Ultrabasic Rocks 659
Zonn S. V. Chemical Composition of Ground Waters as Dependent on Soil Formation 197